The Case Against Carbon Capture: False Claims and New Pollution

The United States is one of the biggest contributors to climate change through fossil fuel emissions.[1] If the planet warms more than 1.5 degrees Celsius, increased temperatures could cause irreversible damage, potentially making parts of the world uninhabitable this century.[2] To avoid the 1.5 degree tipping point, we must rapidly decarbonize our grid and hit net zero global emissions by 2050.[3] This requires a transition to 100 percent renewable energy,[4] and not the technological band-aids that utilities, drillers and petrochemical companies push to alleviate their climate culpability.

A central false solution is carbon capture and storage (CCS), which captures and stores carbon dioxide (CO_2) from smokestacks or the atmosphere. CCS would waste public money to lock in and double down on the dirty footprint of fossil fuels through the creation of an entirely new dangerous industry. CCS, with its many side effects and questionable efficacy, distracts us from real climate solutions.

Findings:

- Despite billions in public support, CCS technology has not met deployment expectations. An examination of CCS projects reveals extensive delays, cost overruns and cancellations. Once built, CCS is incapable of competing with other energy sources without ratepayer or taxpayer bailouts.

- Based on the application of CCS technologies to meet 2018 electricity demands, Food & Water Watch found that while renewable energy technologies can virtually eliminate greenhouse gas emissions from electricity, equipping coal- and natural gas-fired plants with CCS would only reduce greenhouse gas emissions by 39 percent. Such a scenario could support a 35 percent increase in coal production and a 13 percent increase in natural gas production. CCS is particularly incompatible with a transition to natural gas. Replacing all coal- and natural gas-fired plants with natural gas-fired CCS plants would only reduce emissions by 25 percent and would enable natural gas production to increase by 33 percent.
- If all power plants used CCS, they would burn 39 percent more natural gas and 43 percent more coal, thereby exacerbating air and water pollution impacts, which fall disproportionately on lower-income people and communities of color.
- Large quantities of captured CO_2 create a new dirty infrastructure footprint. Unproven schemes that store CO_2 mean more groundwater contamination, air pollution and earthquakes.

Carbon Capture: A Lifeline for the Fossil Fuel Industry

CCS is an unproven technology that would prop up polluters and boost fossil fuel demand. Widespread adoption would be a windfall for fracking and coal corporations as CCS-equipped power plants burn more fuel to produce the same amount of electricity.[5] Pipeline companies would also benefit from a CCS building spree.[6] By retrofitting industrial emitters with CCS technology, potentially at tax- or ratepayer expense, companies would profit from the very investments responsible for climate chaos.

Despite climate concerns, major energy companies dump billions into new fossil fuel projects while investing less than 1 percent of their capital in low-carbon energy.[7] CCS is a useful way for fossil fuel companies to avoid a write-down of their toxic assets. Producers increasingly pitch “clean coal” (capturing carbon emissions from burning coal and storing them underground), a central part of the Trump administration’s coal revival.[8] The “magic” of CCS is also increasingly embraced by natural gas proponents.[9]

When CCS is combined with biofuels (like biomass) or direct air capture (catching CO_2 dispersed in the atmosphere), it unlocks dangerous and speculative “negative emissions” narratives — fables that delay real climate action with the promise of a super technology that would stop the climate crisis.[10] The World Coal Association notes that even the Intergovernmental Panel on Climate Change (IPCC) supports CCS, particularly in combination with biomass (see page 5)[11] — a polluting energy such as burning wood. Subsequently, some well-funded national environmental organizations have uncritically swallowed the fallacious talking point that CCS is both necessary and capable of meeting climate demands.[12]

And in the face of the industry’s self-induced financial crisis,[13] CCS soothes investors. These financial interlocks could explain the bipartisan effort to jam CCS subsidies into federal legislation.[14] At the state level, industry is beginning to extract tax concessions, dangerous liability reforms and pooling reforms that would force partial owners to accept carbon storage on their property.[15]

Climate Safety Should Not Be Held Hostage by CCS

Dirty industries say CCS is necessary to meet climate goals, dismissing real solutions.[16] Technology exists to support a transition to 100 percent clean, renewable energy backed up by storage and transmission at prices lower than current energy costs.[17] While some contend that renewables require dispatchable generation to function, a variety of energy storage technologies can provide cost-effective, reliable, long-term backup for a 100 percent renewable energy system.[18] This use of electricity storage has been demonstrated at scale and is energetically more efficient than CCS.[19]

Experts agree that the cornerstone of climate action is decarbonizing the electric grid, which will foster the decarbonization of other sectors like transportation and buildings through electrification.[20] The most ambitious forms of CCS only reduce emissions by 90 percent; but when emissions associated with the operation of capture facilities are considered, reductions fall to near 80 percent.[21] When methane emissions from increased production are factored in, CCS can only reduce electricity sector emissions by 39 percent (see Figure 1).[22]

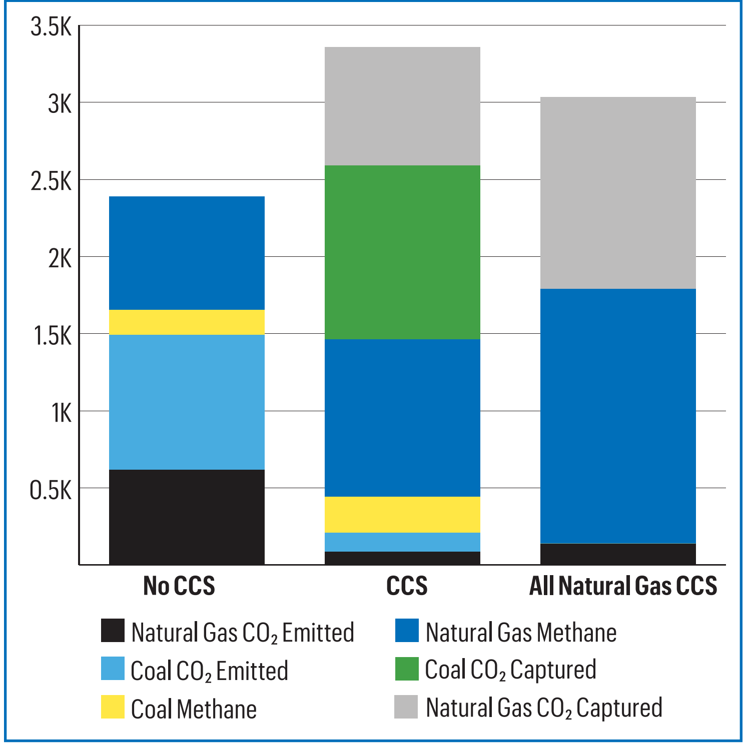
The environmental, health and economic impacts of fossil-fueled power plants and the extraction that these plants drive are not limited to carbon emissions. Burning fuels to produce electricity emits dangerous air pollution, depletes scarce water resources and generates large quantities of toxic waste.[23] Adapting power plants to capture carbon will simply worsen the pollution burdens felt by nearby communities, which are disproportionately lower income and communities of color.[24]

More Pollution for the Same Electricity: CCS Supercharges Demand for Fossil Fuels

From capture to injection, CCS requires huge amounts of electricity.[25] A fraction of the fuel must be dedicated to CCS operations, which reduces a power plant's electric output (otherwise referred to as the "energy penalty".)[26] To compensate for decreased efficiency, generators must expand and burn more fossil fuels to produce the same amount of electricity.[27] This means that when CCS proponents point to "CO_2 captured" as a metric of success, they hide the increase in CO_2 emissions from additional combustion.[28] For example, our nation's only successfully retrofitted CCS power plant built an entirely new polluting power plant to run the capture system.[29]

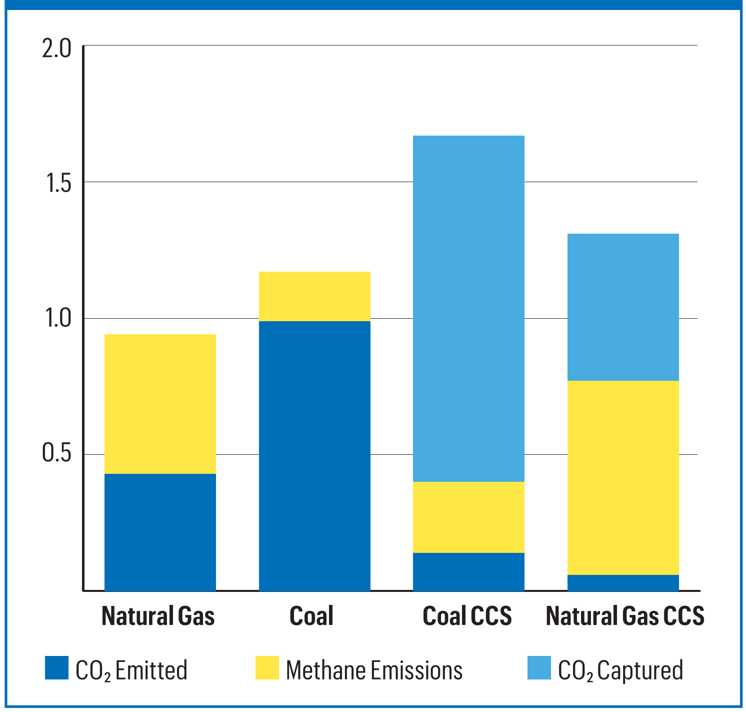
Based on our analysis, retrofitting natural gas and coal plants with CCS while producing the same amount of electricity could raise natural gas and coal production by 13 percent and 35 percent, respectively.[30] If all coal and unequipped natural gas plants were replaced with natural gas CCS facilities, gas production could increase by 33 percent.[31] Our analysis also found that after accounting for increased methane emissions, full deployment of 90 percent-effective CCS would reduce power sector emissions by only 39 percent.[32] Switching to an all-gas CCS system would reduce emissions by only 25 percent (see Figure 1).[33] Due to increasesed methane emissions, equipping natural gas plants with CCS only reduces greenhouse gas emissions by 18 percent (see Figure 2).

Figure 1: 2020 Electricity Emissions Profile CCS and Conventional (MMT CO_2eq)



SOURCE: Food & Water Watch analysis of EIA data.

Figure 2: 2020 Electricity Emissions Technology Comparisons (Metric Tons CO_2eq/MwH)



SOURCE: Food & Water Watch analysis of EIA data.

Compounding Environmental Impacts from CCS

Power plants and their supply chains are responsible for ongoing, large-scale pollution. They taint air and water with dangerous byproducts of fossil fuel combustion and harm exposed communities. Not only will CCS keep these plants open, but if all power plants used CCS, they would burn 39 percent more natural gas and 43 percent more coal.[34]

Water Issues

Power plants need large quantities of low-temperature water for cooling.[35] Thermoelectric power plants are one of the largest water users,[36] accounting for 38 percent of all U.S. freshwater withdrawals in 2010.[37] Power plants not only drain water resources, but increased water shortages undermine their long-term cost effectiveness and reliability.[38] From 2007 to 2008, warmer, drier periods caused U.S. plants to cut production, conditions that can send prices soaring.[39] Researchers found that climate change will make extreme shortages (defined as a 90 percent or greater reduction in power production) three times more likely.[40] In addition to preserving an unsustainable electricity system, CCS will further increase power plant water usage.[41]

In addition to water use, coal plants produce potentially hazardous unburned coal residue that can contain arsenic, boron, cadmium, chromium, iron, copper, lead, manganese, mercury and selenium.[42] CCS would produce a new stream of untreated wastewater.[43] Scrubbing chemicals emitted in low quantities from carbon capture devices could contaminate water supplies with probable carcinogens.[44]

Air Pollution

Power plants release air pollutants like mercury, particulate matter, sulfur dioxide (SO_2) and nitrogen oxides (NO_x).[45] Their SO_2, NO_x and particulate matter pollution contributes to respiratory health problems (such as chronic bronchitis, asthma, emphysema and existing heart disease), causes labored breathing and reduces life expectancy.[46] Particulate matter pollution from power plants is responsible for 15,000 premature deaths annually.[47]

Georgia Power's Plant Scherer is one of the largest coal-fired thermoelectric power-production facilities in the United States.

Without new scrubbers, additional fuel consumption to offset the energy penalty will increase these emissions.[48] In addition to emissions associated with fuel combustion, emission of carbon separation solvents such as monoethanolamine (MEA, a compound about as toxic as cyanide) could cause toxic exposure and smog formation.[49]

Extraction

Extraction of vast quantities of fossil fuels for electricity production shifts intense health and environmental burdens onto the communities where production takes place. Communities plagued by fracking experience well-documented, severe environmental impacts.[50] Black lung impacts an increasing proportion of coal miners,[51] and mountain-top mining increases hazardous dust exposure and stream pollution with serious potential for human health impacts. Researchers have also found higher birth defect and respiratory illness rates in areas with mountain-top mining, compared to those without.[52]

The purported climate benefits of carbon capture are offset by the increased emissions from production, processing and transportation. Both coal mining and natural gas production emit large quantities of methane, a greenhouse gas that is 86 times as potent as CO_2 over 20 years and 34 times as potent over 100 years.[53] Methane emissions add up quickly. For natural gas, a loss rate of 2.3 percent of methane emissions from the supply chain produces the same amount of warming as the CO_2 emitted from combustion.[54] Recent research finds a 4.0 percent leakage rate for shale (fracked) gas and a 2.67 percent leak rate for other natural gas.[55]

Carbon Capture Is Insufficient to Address Other Industrial Emissions

While clean electricity can be an antidote to the energy sector and provide carbon-free heat, 14 percent of industrial carbon emissions are intrinsic to the core chemistry of these industries.[56] CCS could theoretically be applied to a range of industrial practices that emit CO_2, such as the production of fertilizer, plastic, steel and cement.[57] In some cases, alternative ways of supplying these end products exist, but in others, continued research and development is urgently necessary.

Petrochemicals. Much of the petrochemical industry can be scaled back without resorting to CCS by producing fewer unnecessary products, such as disposable single-use plastics.[58] (Increased petrochemical manufacturing is projected to drive a 40 percent increase in global plastics production over the next decade.[59]) For necessary plastics (such as medical devices or building materials), carbon-free alternatives exist. It is possible to produce plastic and other complex hydrocarbons using renewable electricity.[60] Companies are already investing in large-scale renewable-powered manufacture of hydrogen to replace traditional petrochemicals.[61]

Cement and Steel. Key construction materials like steel and cement need real decarbonization solutions, not false promises. Steel, cement and iron have very diluted carbon emission streams, making carbon capture challenging.[62] While carbon-free steel production methods need new research and development, some methods show promise. In 2013, MIT researchers laid the groundwork for an affordable, entirely electrified, carbon emission-free steel production technique.[63] Another method uses renewably-produced hydrogen to produce steel from iron.[64] Carbon capture in the cement industry faces unique challenges.[65] Technologies capable of reducing emissions by more than 64 percent remain prototypes.[66] Alternative cement production methods and products are still undergoing research, but several carbon-free options appear viable.[67]

Negative Emissions: Dangerous, Costly, Unproven

Negative emissions technologies can supposedly remove CO_2 from the atmosphere. They may also produce energy in addition to clawing back CO_2. But their promise is an excuse to delay urgently needed emission reductions.

Capturing Dirty Bioenergy

Despite the technical barriers to biomass energy and its extravagant land-use requirements, the IPCC's fifth assessment report heavily promotes the development of dirty bioenergy combined with CCS.[68] While capture of carbon emissions from conversion of biomass to liquid fuel is possible, the resultant biofuel emits CO_2 when burned.[69]

Bioenergy's supposed carbon neutrality hinges on the faulty assumption that growing plants offsets fuel combustion.[70] While combustion emissions are immediate, it may take years for photosynthesis to reabsorb equivalent emission amounts.[71] For example, using wood instead of coal increases short-term carbon emissions.[72] U.S. pellet plants (which supply generators) overwhelmingly source from trees rather than from waste residues or byproducts.[73]

Bioenergy production competes with land uses for habitation, conservation and food production.[74] Deriving less than 10 percent of global energy from the most efficient biofuel sources would require between 11 percent and 14 percent of arable land and between 18 percent and 25 percent of current human water consumption.[75] Heavy use of biofuels could require up to 80 percent of current cropland.[76] To give a sense of the land requirements, bioenergy ambitions are limited by the existence of natural parks.[77] This increased land scarcity would have catastrophic impacts on food availability and biodiversity.[78]

Bioenergy CCS is likely an expensive boondoggle. Capturing CO_2 adds costs to the already expensive biofuel technology.[79] U.S. biofuels are also poorly suited to CCS because they need substantial energy inputs relative to the energy they generate.[80] Far from being carbon negative, biofuel's low energy content and high moisture content could make the net CO_2 reduction from capturing biomass worse than fossil-fueled CCS.[81] Additionally, biomass air emissions include many of the same pollutants as coal plants, with some worse respiratory effects.[82]

Direct Air Capture

One of the most speculative carbon capture schemes, direct air capture (DAC), involves pulling carbon directly out of the atmosphere.[83] This process is incredibly inefficient because CO_2 in ambient air is 100 to 300 times more diluted than typical smoke-stack emissions.[84] DAC plants are massive and require colossal amounts of energy to operate.[85] Functional DAC is essentially bad energy storage that requires a fully renewable grid; if powered with natural gas or coal, the process releases more CO_2 than it captures.[86]

Existing pilot-scale DAC facilities are surprisingly huge, and full-scale plants would consume as much land as the coal plants that they would offset.[87] Contemporary air capture also uses as much as 50 tons of water for every ton of CO_2 captured.[88] These limitations mean that DAC cannot be feasibly deployed at a scale sufficient to meaningfully impact atmospheric CO_2 levels.[89]

CCS: Expensive and Ineffectual

Despite billions in government handouts, power plant CCS technology remains prohibitively expensive and has not lived up to optimistic projections over the past two decades.[90] In 2009, President Barack Obama's energy secretary, Steven Chu, predicted that the United States would have 10 coal-fired plants with CCS in service by 2016.[91] Between 2005 and 2012, the U.S. Department of Energy (DOE) spent $6.9 billion attempting to demonstrate the feasibility of CCS for coal.[92] By 2012, 4 of the 10 predicted projects were cancelled or mothballed, 5 of which received a combined $2 billion in DOE funding.[93] Only three projects came to fruition.[94] One, the Petra Nova power plant, captures a tiny fraction of site emissions at an astronomical cost.[95] Another captures the emissions from a hydrogen production facility.[96] The third captures easy-to-trap biofuel refining emissions from an Archer Daniels Midland (ADM) plant to produce fuel that will emit CO_2 when burned.[97]

Between 2014 and 2016, less than 4 percent of the planned CCS capacity was deployed.[98] Now, after support from both the Bush and Obama administrations, cost estimates for power plants with CCS are substantially higher than in 2005.[99] Despite lackluster results, the DOE continues to dump millions on speculative carbon capture ventures.[100]

Based on the current pace of demonstration projects, a deployment schedule that meets climate demands is increasingly implausible. In 2012, energy researchers heralded that it was the "last chance for CCS."[101] The International Energy Agency has steadily revised CCS deployment targets downward as progress has slowed.[102] And despite ongoing public proclamations, large utilities and oil companies have abandoned CCS without subsidies.[103] In an extensive evaluation of the divergence between CCS predictions and actual deployment, a *Global Environmental Change* article remarked that "CCS hype was driven by the expectations and commitments of the close-knit community of expert-advocates that formed around CCS in the early to mid-2000s."[104]

Based on the current pace of demonstration projects, a deployment schedule that meets climate demands is increasingly implausible.

Continued optimism around natural gas CCS is remarkable since no commercial-scale gas-fired power plants have successfully adopted carbon capture, and capturing the diluted CO_2 from gas-fired power plants may be harder than capturing CO_2 from coal plants.[105] Without scientific breakthroughs, CCS may remain perpetually "one decade away."[106]

Utilities Will Bill Ratepayers for CCS

Utility companies exercise exceptional power over consumers, sometimes forcing ratepayers to pay for closed power plants.[107] Putting CCS on the government or ratepayer tab would be an expensive bailout for dirty energy producers. If successfully deployed by utilities, carbon capture technologies would increase generating costs by up to 80 percent.[108]

Prior attempts to build CCS have resulted in catastrophic cost blowouts. Southern Company's Kemper plant was supposed to cost $2.9 billion, but projections ballooned to $7.5 billion, $270 million of which came from the DOE.[109] After years of delays and facing $5 billion in increased costs, Southern Company scrapped the CCS portion of the project and runs Kemper as a standard gas plant.[110]

Even the rare CCS success stories are uninspiring. "On budget and on time" appears constantly in descriptions of the Petra Nova CCS retrofit.[111] Ironically, to meet the energy needs of the carbon capture system, Petra Nova had to build a new gas plant.[112] The combustion emissions from the new gas plant (ignoring upstream methane leaks) lower the Petra Nova plant's capture rate from a touted 90 percent to an actual 66 percent.[113] These insignificant emission reductions incurred a cost of $1 billion, $167 million of which came from the DOE — or $4,200 per kilowatt of capacity that was retrofitted.[114] (For context, Lazard estimates that the cost of new gas capacity is between $700 and $1,300 per kilowatt.[115]) In addition to the DOE grant, Petra Nova sells the CO_2 to oil drillers for use, but these sales do not fully cover the costs of the retrofit.[116]

The other CCS "success" is the Canadian SaskPower's Boundary Dam, a 110-megawatt coal plant.[117] To secure project funding, the Canadian government had to pick up $300 million of the colossal $1.3 billion price tag.[118] Although the plant is operating, internal documents reveal that it experienced numerous operational problems, adding millions to the cost of the project and severely limiting the plant's carbon capture capacity.[119] SaskPower's experience with the Boundary Dam plant led the corporation to cancel plans for larger CCS plants.[120]

Deployment Poses Insurmountable Challenges

Despite many failures, proponents misguidedly advocate for retrofitting old plants with CCS. Even if the technology worked, the buildout would likely be too slow to meet climate needs.[121] 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.[122] Adding carbon capture to older plants approaches the cost of building power plants from scratch.[123]

Even perfect CCS fails to fix the global climate crisis because other countries will never have an incentive to install it.[124] Oddly, the inverse of this argument is frequently proffered by CCS proponents who say: "Go tell China and India and Indonesia to stop burning coal. They'll say no. Countries are going to continue to use coal for electricity."[125] This is precisely the problem with CCS. While renewables plus storage, if sufficiently developed and demonstrated, is likely to compete with and close coal plants on cost alone, scrubbing technology will always be more expensive than unfiltered coal.[126] Only developing cost-competitive technologies can drive voluntary international decarbonization and create a stable foundation for international climate accords.[127]

Enhanced Oil Recovery, Storage and a Pipeline of Infrastructure Problems

Carbon capture boosters love the concept of using CO_2 in commercial products because it would create a revenue stream for carbon capture while avoiding storage.[128] Products that use carbon, such as soda and canned goods, often emit it back into the atmosphere after use.[129] Additionally, the total potential for use in products is only a small fraction (less than 10 percent) of overall carbon emissions.[130] Conversion of the CO_2 to usable products requires energy (and attendant emissions), in some cases offsetting the purported benefits of using the carbon.[131] That is why even product-utilization optimists admit that CO_2 for oil extraction is likely to remain its dominant use in the foreseeable future.[132]

CO_2 enhanced oil recovery (EOR) is an oil production method that uses captured carbon injected into mature, low-pressure oil reservoirs to drive remaining oil to the surface. EOR operations often mix CO_2 with hundreds to thousands of tons of dangerous surfactants and nanoparticles underground to increase oil output.[133] Release and leakage of these surfactants poisons wildlife, and while the human health impacts of nanoparticle additives are poorly understood, new research demonstrates potential liver and kidney impacts from exposure.[134]

The primary goal of EOR is maximizing oil production, not storing carbon.[135] Mature oil fields in which EOR typically takes place pose unique challenges and are less studied than the salt water reservoirs frequently examined for storage.[136] Maximizing oil production may also require injecting CO_2 at pressures capable of fracturing underground rock formations that contain CO_2, which would enable rapid leakage.[137] In one studied oil field, EOR operators were unable to account for 22 to 96 percent of the CO_2 they injected after a short period.[138]

EOR results in more carbon emissions than it stores. A ton of CO_2 produces 2 to 3 barrels of oil when injected; when burned, that oil emits around 1.2 tons of CO_2.[139] Demand for EOR is insufficient to financially support capturing carbon. As of 2018, 140 CO_2 EOR projects produced approximately 0.35 percent of global oil production.[140] Even the most (unproven) optimistic projections of carbon capture supporters admit that EOR could only utilize around six years of U.S. CO_2 emissions.[141]

Unavoidable CO_2 Infrastructure Leaks

CCS infrastructure poses numerous health and safety risks because carbon is prone to leakage during transport, injection and long-term storage.[142] Concentrated CO_2 is denser than air, and exposure to concentrations higher than 10 percent is potentially fatal.[143] The impact of CO_2 leaks can be dire. In 1986, Lake Nyos in Cameroon released a large bubble of CO_2 that had accumulated from volcanic activity.[144] The CO_2 formed a low-lying cloud, spreading and killing 1,746 people (some more than 15 miles away) and displacing 4,430 more.[145] Captured CO_2 may also contain dangerous impurities such as volatile organic compounds (VOCs), mercaptans, mercury and nitrous oxides, and removing them increases the energy penalty and other environmental impacts of carbon capture.[146] Unremoved, some impurities are corrosive, increasing the odds of leakage.[147]

To ensure climate safety, polluters must guarantee that carbon can be stored for thousands of years, but long-term stable storage of CO_2 remains largely unproven.[148] Existing storage projects have not been able to prove that CCS actually works because underground CO_2 imaging technology is nascent.[149] Despite this, pro-CCS state legislators are moving bills that would shift the financial liability of long-term storage onto the public.[150] Storage optimists cite efforts to control methane leakage as purported proof that CO_2 leakage is fixable, despite ongoing substantial methane emissions from natural gas production.[151]

Cameroon's Lake Nyos, approximately two weeks after releasing a large eruption of CO_2, creating a cloud that killed 1,746 people and displacing 4,430 more.

Well failure during injection or a blowout could release large amounts of CO_2.[152] Injection pressure can also reactivate fracture networks or deform the sealing layer, allowing leaks.[153] CO_2 must be injected under sufficient pressure to displace existing fluids. In small spaces, this can create rapid pressure increases that fracture containment layers.[154] Earthquakes from injection could also rupture storage seals, allowing CO_2 to leak.[155] The increased pressure is compounded by chemical reactions between the brine, CO_2 and minerals that can increase the permeability of the sealant layer.[156]

Natural variations in subsurface geology potentially allow CO_2 to rise to the surface unless trapped by sealing layers of rock.[157] For example, CO_2 can flow through water channels that may be connected to the surface.[158] Slower leakage along fractures and undetected faults is also possible.[159] Dependent on rock permeability, as much as 10 percent of stored CO_2 may leak over 30 years.[160] These unknown factors are amplified by natural disasters such as earthquakes.[161]

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.[162] Any old, unsealed or defectively-sealed wells are essentially pipelines to the surface.[163] CO_2 can also slowly escape along well linings and has been shown to corrode materials used in well casings and seals.[164] Undetected leaks can completely undermine a storage operation's efficacy.[165] Optimists reference similarities to natural gas storage, ignoring the disastrous Aliso Canyon blowout that spewed methane for months.[166] Storage leaks could also contaminate groundwater and soil.[167]

CO_2 Pipelines, Like Natural Gas Pipelines, Would Be Faulty

A buildout of CCS infrastructure could propel pipeline companies into a pipeline building bonanza. Like natural gas pipelines, CO_2 leaks are likely to occur in every stage of the CCS network — from EOR wells to pipelines to compressor stations to power plants and their storage facilities. Moreover, CO_2 pipeline accidents could release large quantities of dense gas, which may temporarily accumulate in low-lying areas as incredibly dangerous ground-level CO_2 clouds.[168]

Much like natural gas, CO_2 pipelines require compressor stations to maintain pressure.[169] These facilities are integral to moving content through pipeline networks, but emit air pollutants like NO_x, fine particulate matter, carbon monoxide, benzene and formaldehyde (some of which are associated with an increase in ambient ozone).[170] In Pennsylvania, noisy compressor stations are the leading cause of air pollution from oil and gas production.[171]

CO_2 Storage and Injection Is Shaky at Best

Another caveat to CCS is inadequate space for safe underground carbon storage. Pro-CCS studies tend to evaluate only abstract CO_2 storage capacity (such as global and national capacities) without regard to practical limitations (such as transportation of CO_2 and conflicting land uses).[172] In commercial settings, suitable CO_2 storage reservoirs may be far from carbon-emitting sources or functionally limited due to injection rates (the reservoir can only accept CO_2 at a lower rate).[173] Injecting CO_2 at rates above the pressure tolerance of a specific reservoir can crack seals, activate faults and cause earthquakes and leaks.[174] Sequestration also fails to provide a global answer to the climate crisis since some countries do not have rocks suitable for CO_2 storage.[175]

Extensive research has also linked high-volume injection (for wastewater disposal and natural gas storage) to earthquakes. Carbon sequestration plans would inject CO_2 at volumes higher than activities already linked to seismicity.[176] Not only is CO_2 injection very similar to wastewater injection, but reducing pressure to inject CO_2 may require extracting wastewater from the reservoir and reinjecting elsewhere.[177] Extensive research links fluid injection and disposal to earthquakes.[178]

Research links injection of CO_2 to seismecity.[179] Events with magnitude as high as 4.4 have been recorded at CO_2 injection sites, which is near levels that can damage buildings and infrastructure and contaminate drinking water.[180] These seismic risks will increase if CCS is commercialized and volumes of injected CO_2 grow beyond what occurs at current demonstration projects.[181]

Conclusion

Despite the proven viability of every technological component necessary for a rapid transition to 100 percent clean, renewable energy,[182] embedded interests continue to promote carbon capture and storage as a solution to climate change. Successful deployment of this technology would result in large increases in pollution associated with the extraction, transportation and combustion of fossil fuels, burdens that are borne disproportionately by the least well-off in society. At the same time, CCS would fail to meaningfully reduce emissions to stave off the worst effects of climate chaos.

Carbon capture and storage relies on unproven and dangerous technologies that cannot survive without government support. Continued subsidies for this failed technology only serve as an excuse to defer meaningful climate action. A reckless push for CCS would sacrifice important regulatory guardrails and expose the public to increased water pollution, induced earthquakes and potentially catastrophic releases of CO_2.

Methodology

Food & Water Watch used the electricity emissions model from our report *Fracking's Bridge to Climate Chaos: Exposing the Fossil Fuel Industry's Deadly Spin* to estimate the impact of CCS on emissions and fuel use (assuming the technology was deployed on the 2020 fleet of natural gas- and coal-fired power plants). The model was updated to include uncounted leakage from the portion of natural gas fuel lost between production and delivery at electric power plants. Tonnes of methane were converted to tonnes of CO2 equivalents using the 20 year global warming potential of methane. The model uses data from the Reference Case projections of the Energy Information Administration's Annual Energy Outlook 2020 released January 2020.

Food & Water Watch used an energy penalty of 30 percent for coal based on the retrofit at Boundary Dam and a review of estimated penalties for retrofits found in the literature.[183] Due to the lack of scale demonstrations of CCS at natural gas-fired power plants, our analysis used a high estimate (28 percent) for the energy penalty of natural gas plants.[184] Our results are likely conservative as energy penalty calculations do not always include the energy use associated with pipeline transport, pressurization and injection.[185] Our analysis assumed that reduced output was met by a corresponding increase in output from the same type of plant, also equipped with carbon capture (for example, a 30 percent reduction in output from a CCS equipped coal plant would be met with a corresponding increase in generation from a CCS-equipped coal plant).

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