March 2022

Carbon Capture and Storage Policy Position

The Climate Center Policy Guidance

the climate center

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Introduction

The latest climate science indicates that global temperatures will likely surpass the 1.5C threshold of dangerous warming as soon as 2030 or earlier.[1] As outlined in the IPCC's Sixth Assessment Report (2021), we must act immediately to avert catastrophic climatic change through massive greenhouse gas emissions reductions *and* removal of up to one trillion tons of climate pollution from the atmosphere.

The Climate Center's flagship Climate-Safe California (CSC) Campaign aims to dramatically accelerate climate action in California through bold, equitable policies, catalyzing the nation and the world into greater action. CSC focuses on achieving net-negative emissions in California by 2030 through deep emissions cuts along with

[1] Yangyang Xu, Veerabhadran Ramanathan and David G. Victor.. **Global warming will happen faster than we think**. Nature. December 5, 2018. https://www.nature.com/articles/d41586-018-07586-5; IPCC, 2021; and Zeke Hausfather. **Analysis: What the new IPCC report says about when world may pass 1.5C and 2C.** Carbon Brief. October 8, 2021. https://www.carbonbrief.org/analysis-what-the-new-ipcc-report-says-about-when-world-may-pass-1-5c-and-2c

significant natural and working lands carbon sequestration. CSC is guided by three principles: adhere to the latest climate science, ensure climate justice, and foster a just transition for fossil fuel workers, their families and their communities.

The use of carbon capture and storage (CCS) technology is increasingly under discussion among policymakers, environmental advocates, and the public as one of multiple potential solutions in the toolbox of climate mitigation. This paper describes how CCS works, examines how it intersects with the guiding principles of CSC, and clarifies if and when The Climate Center might support it.

What is Carbon Capture and Storage?

CCS is a technological means of carbon dioxide (CO_2) removal (CDR) "at the smokestack" (not after it has entered the atmosphere as in Direct Air Capture). CCS removes CO_2 from the exhaust of fossil fuel electricity generation or industrial plants and then converts it to liquid for transport by pipeline, trucks or ships. The goal is to then store the CO_2 geologically in spent underground oil and gas formations, deep saline aquifers, coal beds and marine settings.[2]

It is also possible to "utilize" the captured CO_2 by converting it to an inert solid, or injecting it during "enhanced oil recovery" (EOR) to produce additional fossil fuels. This process is sometimes referred to as carbon capture, utilization, and storage (CCUS).[3] One recent analysis found that 81% of CO_2 recovered from CCS is used for EOR.[4] Concerns about CO_2 leaks from EOR in transportation and storage have been raised by the IPCC.[5] In 2016, an Exxon EOR field in Wyoming repeatedly leaked next to a public

[2] Vincent Gonzales, Alan Krupnick, Lauren Dunlap. **Carbon Capture and Storage 101**. *Resources for the Future*, 2020. https://www.rff.org/publications/explainers/carbon-capture-and-storage-101/

[3] **What is carbon capture and storage and what role can it play in tackling climate change?** London School of Economics. May 1. 2018. https://www.lse.ac.uk/granthaminstitute/explainers/what-is-carbon-capture-and-storage-and-what-role-can-it-play-in-tackling-climate-change/

[4] Samira Garcia Freites, Christopher Jones. **A Review of the Role of Fossil Fuel Based Carbon Capture and Storage in the Energy System**. December 2020. https://foe.scot/wp-content/uploads/2021/01/CCS_REPORT_FINAL.pdf

[5] **IPCC, 2018: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels.** https://www.ipcc.ch/site/assets/uploads/sites/2/2019/06/SR15_Full_Re%20port_High_Res.pdf

school, emitting dangerous levels of carbon dioxide pollution that closed the school down.[6] Another study found a strong correlation between earthquakes and EOR.[7]

The findings and recommendations in this paper apply to CCS and CCUS, but for purposes of this policy paper, we refer to both as CCS.

At present, there are 26 operational CCS sites globally including 10 in the United States.[8] The Biden Administration's infrastructure bill, enacted in November 2021, allocates $3.5 billion to fund large, commercial CCS demonstration and pilot projects.[9]

CCS and the Principles of Climate-Safe California

Climate Science

Of the few remaining climate pathways that restrict atmospheric warming to less than 1.5°C, all of them require sizable contributions from carbon dioxide removal *(*CDR) approaches.[10] CDR is a necessary complement to dramatic emissions reductions, and the two must be undertaken in tandem to achieve a climate-safe future.[11] The Intergovernmental Panel on Climate Change states that reaching net zero is required by 2050 to stay below 1.5°C, but recent research suggests that we are approaching 1.5°C faster than anticipated and that 2050 is far too late.[12]

The Climate Center is a strong advocate for natural carbon sequestration (NCS) as a pathway to sequestering significant amounts of carbon in soils since we know how to do it now, it is relatively inexpensive, and it has many co-benefits. A recent report by The Climate Center suggests that California can sequester up to 103 million metric tons of carbon dioxide equivalent (MMT CO_2e) per year from the atmosphere by 2030 using NCS

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[6] Nicholas Kusnetz. **Exxon Touts Carbon Capture as a Climate Fix, but Uses It to Maximize Profit and Keep Oil Flowing**. *Inside Climate News.* September 27, 2020. https://insideclimatenews.org/news/27092020/exxon-carbon-capture/

[7] ScienceDaily. **Gas injection probably triggered small earthquakes near Snyder, Texas.** *ScienceDaily.* November 4, 2103. https://www.sciencedaily.com/releases/2013/11/131104152726.htm

[8] Freitas and Jones. 2020.

[9] DOE. **The Infrastructure Investment and Jobs Act: Opportunities to Accelerate Deployment in Fossil Energy and Carbon Management Activities.** *Department of Energy*, 2021. https://www.energy.gov/sites/default/files/2021-12/FECM%20Infrastructure%20Factsheet.pdf

[10] Lila Warszawski, Elmar Kriegler, Timothy M. Lenton, Owen Gaffney, Daniela Jacob, Daniel Klingenfeld, Ryu Koide, María Máñez Costa, Dirk Messner, Nebojsa Nakicenovic, Hans Joachim Schellnhuber, Peter Schlosser, Kazuhiko Takeuchi, Sander van der Leeuw, Gail Whiteman, Johan Rockström. **All options, not silver bullets, needed to limit global warming to 1.5°C: a scenario appraisal.** *Environmental Research Letters*, 2021; DOI: 10.1088/1748-9326/abfeec https://iopscience.iop.org/article/10.1088/1748-9326/abfeec

[11] Daniel M Kammen, Teenie Matlock, Manuel Pastor, David Pellow, Veerabhadran Ramanathan, Tom Steyer, Leah Stokes, Feliz Ventura. **Accelerating the timeline for climate action in California**. *ArXiv*, 2021. https://arxiv.org/abs/2103.07801

[12] Ibid.

on working lands alone.[13] This sequestration potential increases further when natural lands are included. NCS can also accrue co-benefits to water and food security, pollution reduction, and resilience to extreme weather. While NCS is an important CDR strategy, technological forms of CDR are in development. Some analyses expect that technological CDR, which includes CCS and direct air capture (DAC), could play a significant role in future climate mitigation efforts.

Climate Justice

The environmental justice (EJ) and climate justice communities have long raised concerns over CCS. The oil and gas industry has publicly framed CCS as a climate solution. When used with fossil fuel power generation, however, CCS serves to enable continued fossil fuel extraction and pollution. This most directly and strongly impacts fenceline, Black, Indigenous, People of Color (BIPOC) and working class communities. With CCS deployed at scale, the drilling, mining, extraction, and transport of fossil fuels could continue, with all the attendant public health problems. And because CCS captures CO_2 and not other pollutants, the most toxic fossil fuel emissions are still released into nearby communities.

Opposition to CCS from EJ organizations has been fairly loud, consistent, and unified. Groups have voiced this position in multiple venues, including a highly publicized letter from over 500 organizations urging the Biden Administration to reject CCS,[14] as part of Climate Justice Alliance's memo on the subject,[15] in the White House Environmental Justice Advisory Council,[16] and in editorials.[17] Given the historic pollution burdens that have most strongly affected lower income and BIPOC communities, CCS used at fossil fuel plants is a violation of environmental justice and fails to redress ongoing inequities.

In 2021, CCS received attention for its placement in AB 1395,[18] a California bill which would have included the technology as a potential solution but put restrictions around its

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[13] The Climate Center. **Setting an Ambitious Sequestration Goal for California's Working Lands: Analysis and Recommendations for Net-Negative Emissions by 2030.** *The Climate Center*, 2022. www.theclimatecenter.org/working-lands

[14] CIEL. **Carbon capture is not a climate solution.** *Center for International Environmental Law*, July 19, 2021. https://www.ciel.org/issue/carbon-capture-and-storage/

[15] Climate Justice Alliance. **Carbon Capture and Storage: A Clear and Present Danger.** *Climate Justice Alliance*, 2020. https://climatejusticealliance.org/wp-content/uploads/2020/11/Carbon-Capture-v4.pdf

[16] Rachel Frazin. **White House environmental justice advisers express opposition to nuclear, carbon capture projects.** *The Hill*, May 17th, 2021. https://thehill.com/policy/energy-environment/553927-white-house-environmental-justice-advisors-expresses-opposition-to

[17] Rocio Madrigal. **Carbon capture's offer of climate-change benefit would make Valley a dumping ground.** *The Fresno Bee*, December 21, 2021. https://www.fresnobee.com/opinion/readers-opinion/article256750032.html

[18] Assemblymembers Muratsuchi and Cristina Garcia. **AB 1395 The California Climate Crisis Act.** *California Legislative Information*, 2021. https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=202120220AB1395

use. Prominent EJ groups spoke out against the inclusion of CCS in the bill. Their objections included concerns that CCS would divert state money from other climate solutions such as renewable energy and long-duration battery storage, and that a focus on a carbon goal alone ignores other air pollutants.[19]

In August 2021, 14 EJ and public health groups, including California Environmental Justice Alliance, Indigenous Environmental Network, the Center on Race, Poverty, and Environment, and Leadership Counsel for Justice and Accountability sent a letter to the state Air Resources Board (CARB) requesting that the agency exclude CCS from its Scoping Plan entirely.[20] The Scoping Plan lays out the state's path to achieving its climate goals. The letter states that CCS "would allow the [fossil fuel] industry to continue externalizing the cost of their business on the backs of the public and EJ communities… [and] would squander billions of dollars in public funds that should be spent on […] holistic solutions pathways that repair the harm done to the health of people and the planet."

The letter asks CARB to prioritize proven and more immediate solutions like "improving local air quality, restoring natural ecosystems, and increasing community engagement, vitality, and jobs."[21]

In March, 2022, EJ organizations sent a letter to the California Senate Climate Working Group stating that "the health burdens experienced by EJ communities living near fossil fuel operations are multi-generational." They called "CCUS a climate dead end on the path to decarbonizing California's economy and building community health, resilience, and safety" and requested that "space be made for our organizations to collaborate with and address the Senate Climate Working Group and bring experts that do not have ties to the fossil fuel industry to explore the full range of impacts, benefits, and burdens of these unproven technologies."

Just Transition

Research suggests that the transition to clean energy is likely to displace roughly 3,200 fossil fuel workers per year between 2021 and 2030 in California.[22] One of the purported social benefits of CCS is its potential to stimulate economic growth and create jobs for

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[19] Emily Pontecorvo. **How a debate over carbon capture derailed California's landmark climate bill.** *Grist*, December 15th, 2021. https://grist.org/politics/carbon-capture-why-california-cant-fill-the-net-zero-gap-in-its-climate-strategy/

[20] Martha Dina Argüello, et al. **Re: 2022 Scoping Plan Update – Engineered Carbon Removal Technical Workshop.** *Physicians for Social Responsibility, Los Angeles, et al., and California Air Resources Board.* August 16th, 2021. https://www.arb.ca.gov/lists/com-attach/29-sp22-co2-removal-ws-B3cAdVQnUS8CaAdm.pdf

[21] Ibid.

[22] Robert Pollin, Jeannette Wicks-Lim, Shouvik Chakraborty, Caitlin Kline, Gregor Semieniuk. **A Program for Economic Recovery and Clean Energy Transition in California.** *Political Economy Research Institute, University of Massachusetts Amherst*, June 2021. https://peri.umass.edu/images/CA-CleanEnergy-6-8-21.pdf

displaced workers or prevent job losses in the fossil fuel sector. Some new CCS jobs may be colocated in regions hit hard by fossil fuel job losses, which could help smooth the workforce transition.

Analysis that quantifies economic benefits from CCS deployment in California is scarce, but one such effort comes out of Rhodium Group. The Group's research indicates that maximizing California's commitment to CCS retrofits and associated pipeline infrastructure would cost $4.0 to $5.4 billion. New job creation would average between 1,430 to 1,880 each year for 15 years, though many of these jobs are short-term construction jobs.[23] Ongoing employment would settle between 880 to 1,200 total jobs.[24] In comparison, one analysis finds that the clean energy transition in California could create 1,044,000 jobs at a total cost of $138 billion, with $68 billion coming from public funds.[25]

Opportunities for displaced oil and gas workers that don't risk extending the fossil fuel era include oil well remediation and plugging, offshore wind, and green hydrogen, among others. By one estimate, oil well remediation alone can produce as many as 9,000 jobs over a ten year period.[26]

Results and Impacts from CCS In Practice

Fossil Fuel Power Generation Applications

CCS technology has existed for decades, though examples of successful deployments at scale are hard to find. Many projects, including high-profile ones like the Gorgon liquefied natural gas hub operated by Chevron in Western Australia and the Southern Company "clean coal" facility in Mississippi, are characterized by cost overruns, project delays, and

[23] Rhodium Group. **The Economic Benefits of Industrial Carbon Capture: Investment and Employment Opportunities for Eastern and Western States.** *Rhodium Group, Great Plains Institute*, 2021. https://rhg.com/wp-content/uploads/2021/01/The-Economic-Benefits-of-Carbon-Capture-State-Investment-and-Employment-Estimates_Phase-II.pdf

[24] Ibid.

[25] Pollin, et al., 2021.

[26] John Cox. **Activists see remediation work as key to 'just transition' away from local oil production.** *Bakersfield.com*, March 1, 2021. https://www.bakersfield.com/news/activists-see-remediation-work-as-key-to-just-transition-away-from-local-oil-production/article_1e8f3cc0-7872-11eb-befc-ab0514a99c07.html

underperformance on capture targets.[27] [28] A 2020 study found that over 80% of proposed CCS projects have "[ended] in failure."[29] Even a CCS facility often touted as a success story, the Boundary Dam Power Station in Saskatchewan, breaks down frequently and captures only 44% of its CO_2, not the promised 90% – and sells much of its captured CO_2 to nearby oil fields to increase oil extraction.[30]

Research from Stanford University looked more deeply into whether CCS plants in operation can deliver on their potential for CO_2 mitigation.[31] According to the 2019 study, power plants require extra energy to run carbon capture technology, and this additional energy increases overall plant emissions, thereby undoing some of the CO_2 benefit. Emissions also increase due to new upstream emissions associated with creating the power supply to run the capture equipment (e.g. methane leaks from natural gas production). While carbon capture technology may absorb some CO_2, it does not capture other pollutants, so fossil fuel plants can still worsen local air quality.

Even powering carbon capture technology with renewable energy still increases total air pollution and social costs relative to no capture. Over a 20-year timeframe at one natural gas powered plant, only 11% of the plant's CO_2e emissions are captured.[32]

Further, there are ongoing concerns relating to whether underground storage is stable and permanent – a leak from the storage site could undo the original CO_2 benefits. Finally, when captured, if CO_2 is used for EOR, it defeats the purpose of attempting to mitigate climate change via CCS.

Industrial Applications

CCS for certain industrial applications presents a different issue set not at the smokestack. In some industries, CO_2 is produced in part from "process emissions," or the byproducts of chemical transformation of materials. Process emissions therefore cannot be eliminated by facility decarbonization through electrification, fuel switching, or energy efficiency.

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[27] Jason Deign. **The carbon capture project that couldn't: Chevron misses targets for its huge Australia facility.** *Canary Media,* 2021. https://www.canarymedia.com/articles/carbon-capture/the-carbon-capture-project-that-couldnt-chevron-misses-targets-for-its-huge-australia-facility

[28] Darren Samuelsohn. **Billions over budget. Two years after deadline. What's gone wrong for the 'clean coal' project that's supposed to save an industry?** *Politico,* 2015. https://www.politico.com/agenda/story/2015/05/billion-dollar-kemper-clean-coal-energy-project-000015/

[29] Ahmed Abdulla, Ryan Hanna, Kristen Schell, Oytun Babacan, David Victor. **Explaining successful and failed investments in U.S. carbon capture and storage using empirical and expert assessments.** *Environmental Research Letters,* 2020. https://iopscience.iop.org/article/10.1088/1748-9326/abd19e

[30] Audrey Carleton. **The World's Only Coal Carbon Capture Plant Is Regularly Breaking.** *Vice*, 2022. https://www.vice.com/en/article/g5q573/the-worlds-only-coal-carbon-capture-plant-is-regularly-breaking

[31] Mark Jacobson. **The health and climate impacts of carbon capture and direct air capture.** *Energy & Environmental Science*, 2019. https://pubs.rsc.org/en/content/articlelanding/2019/ee/c9ee02709b

[32] Ibid.

In cement production, for example, limestone ($CaCO_3$) is heated to very high temperatures and transformed to lime (CaO), which naturally releases CO_2 – a reaction called calcination.[33] This reaction also occurs in iron production, which involves calcination of both limestone and magnesium carbonate ($MgCO_3$ to MgO and CO_2).[34] Steel production involves CO_2 process emissions via carbon oxidation reactions.[35] Process emissions from glass production release CO_2 through calcination of limestone, dolomite, and sodium carbonate.[36]

These sectors are considered "hard-to-abate" for a reason – decarbonizing that part of production requires technologies or processes that are not yet mature or known. Process emissions from cement production, for example, are roughly half of the total industry's emissions, with the other half coming from fossil fuel-based industrial heating, fossil fuels in their power supply, and transportation of materials.[37] In glass production, 15% to 25% of emissions are process-related.[38] In these two industries, electrification with renewables, fuel switching, or energy efficiency can only decarbonize ~50% of cement production and ~75% of glass production. Practices to recycle existing materials, develop novel materials, and substitute materials may be necessary to fully zero out emissions from industrial sectors, but research and development toward this aim are nascent and not ready to scale.[39] Hard-to-abate sectors still need to be decarbonized, and technologies like CCS may (at least temporarily) play a role in helping to eliminate some of the most intractable portions of their carbon footprint.

Industrial scenarios could present legitimate CCS use cases for existing plants, provided they meet certain criteria such as prohibiting use for EOR, reducing co-pollutants that impact the health of nearby communities, and engaging local communities in the planning. The next section describes The Climate Center's position on CCS and criteria to determine whether CCS use should be permitted.

Policy Positions

1) CCS should not be used for carbon capture of fossil fuel smokestack emissions or for EOR under any circumstances.

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[33] Jocelyn Timperley. **Q&A: Why cement emissions matter for climate change.** *Carbon Brief*, 2018. https://www.carbonbrief.org/qa-why-cement-emissions-matter-for-climate-change

[34] Climate Protection Partnerships Division. **Direct Emissions from Iron & Steel Production.** *U.S. Environmental Protection Agency*, 2003. https://www.greenbiz.com/sites/default/files/document/CustomO16C45F66950.pdf

[35] Ibid.

[36] GAE. **The European Glass Sector Contribution to a Climate Neutral Economy.** *Glass Alliance Europe*, 2019. https://www.glassallianceeurope.eu/images/cont/gae-position-paper-on-decarbonisation-june-2019_file.pdf

[37] Timperley, 2018.

[38] GAE, 2019.

[39] Nature Editorial Board. **Glass is the hidden gem in a carbon-neutral future.** *Nature,* November 3rd, 2021. https://doi.org/10.1038/d41586-021-02992-8

a. CCS has an abysmal track record, underdelivering on its CDR targets and costing more than planned. It also gives license to ongoing extraction, refining, and combustion of fossil fuels. The resulting pollution continues to drive climate change and most strongly impacts working class and BIPOC communities.

2) CCS may be used for process emissions in industrial applications from chemical transformation of raw materials (e.g. cement, steel, and glass production) when the captured CO_2 is not used or sold for enhanced oil recovery (EOR). We also recommend that:
    a. Captured CO_2 should be transported and stored in ways that do not harm nearby communities or the environment.
    b. Facilities should work to decarbonize non-process emissions through climate-friendly approaches such as improving energy efficiency, running on renewable energy, and incorporating recycled or substitute materials.
    c. Facilities should actively and rapidly reduce and eliminate non-CO_2 polluting emissions.
    d. Local communities should be meaningfully engaged in the planning of these efforts.
3) Taxpayers should not be the primary source of funds for CCS technology development and deployment.
    a. Private companies and other private sector investors should undertake the bulk of funding and financing of research, development, demonstration, and deployment of CCS technologies.
4) Legislation and regulation for non fossil fuel, industrial process use of CCS should be developed in consultation with diverse interest groups, including historically underrepresented communities.
5) Natural carbon sequestration (NCS) should be the top priority carbon dioxide removal policy approach.
    a. NCS absorbs carbon, holds significantly more water in soil, reduces pollution burdens in frontline agricultural communities, enhances resilience to increasing extremes, and achieves other ecosystem and economic co-benefits. NCS solutions are cost-effective, proven and available.

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