The Colorado Renewable Energy Society
Position on Carbon Management
March 2024

Summary of CRES Position on Carbon Management

CRES opposes the use of state and federal taxpayer dollars and ratepayer funds to deploy unproven carbon management projects in Colorado. This includes the use of direct air capture to remove CO_2 from the atmosphere and the use of carbon capture and storage (CCS) or carbon capture utilization and storage (CCUS) with fossil fuel power plants. CRES believes that climate change impacts have reached a crisis stage and that all current mitigation efforts should be focused on driving carbon emissions to zero or near zero as rapidly as possible. Carbon management does not do this because—unlike renewables—it prolongs the use of fossil fuels.

In particular, funds and policy attention should be invested in the rapid transition of our electric grids to wind and solar energy, in collaboration with the deployment of end-use efficiency, storage, demand response, and transmission. In addition, Colorado should focus on utilizing this carbon-free electricity by electrifying our transportation, buildings, and industry sectors. This means replacing gasoline and diesel cars and trucks with battery electric vehicles, replacing methane gas heating of buildings with ground-coupled and cold-climate heat pumps, and replacing fossil fuels with electricity for the production of industrial process heat.

Introduction and Background

The Intergovernmental Panel on Climate Change (IPCC) has concluded that to achieve "net zero" carbon emissions by 2050, "negative emissions" will be needed to make up for energy uses that are very difficult to abate. The term negative emissions refers to a variety of carbon dioxide removal (CDR) approaches that remove carbon dioxide from the atmosphere. These are generally divided into biological (or "nature-based") methods and non-biological, or mechanical, methods.

Examples of biological solutions include allowing forests to regrow (reforestation), planting new forests (afforestation), restoring coastal wetlands, and switching to regenerative agricultural practices, such as cover crop rotation, that support healthy soils. These biological methods reduce climate change by capturing CO_2 from the air and sequestering it in plants, soils, and sediments. Non-biological means include enhanced rock weatherization and direct air capture. Of all these methods, the one that is receiving the most attention, and is the most expensive, is direct air capture. We address that in the section below on CDR.

CDR methods all attempt to extract carbon dioxide from the atmosphere after it has been added. Of course, it is much easier to not add CO_2 to the atmosphere in the first place, which involves transitioning from fossil fuel energy to renewable energy sources, a transition that is already underway. Because of the enormous extent to which the world relies on fossil fuels, and the large profits of that industry, there is a broad industry effort to explore ways that fossil fuels can

continue to be burned, but with measures taken to capture CO_2 emissions before they enter the atmosphere, then sequester it underground.

Alternatively, CO_2 can be captured before it enters the atmosphere at locations where fossil fuels are used as an energy source (to produce electricity or an industrial product) or as an industrial feedstock. CO_2 can also be captured where it is released as an industrial process emission, such as in the production of Portland cement from limestone.

When CO_2 is captured at a fossil-fueled electric generating plant, it can be captured in three possible ways: 1) pre-combustion (in which the fuel is gasified, and hydrogen and CO_2 are separated), which is only applicable for new fossil fuel power plants, 2) post-combustion (capture of CO_2 in the flue gas), or 3) oxyfuel combustion (burning in pure oxygen, which provides a high-concentration CO_2 exhaust).

Regardless of how CO_2 is captured, be it before or after it enters the atmosphere, a key requirement is that it be stored with some degree of permanence, preferably for time periods much greater than a century. Different methods of carbon capture and storage (CCS or, when utilization is included, CCUS) provide different degrees of permanence. Geologists indicate that the most permanent form of sequestration is via deep geological burial, either in salt caverns or where it is allowed to chemically combine with existing rock when buried.

Regardless of where CO_2 is stored, it will be transported by pipeline. Leaks of CO_2 are extremely hazardous because CO_2 is heavier than air and blankets the ground, leading to the suffocation of animals and human beings. In 1986, CO_2 leakage from Lake Nyos, a volcanic crater lake in Cameroon, West Africa, resulted in the deaths of approximately 1,700 people located 17 miles from the lake.[1] In February 2020, in Satartia, Mississippi, a CO_2 pipeline ruptured. More than 200 people were evacuated and at least 45 people were hospitalized. Automobile engines stalled, hobbling emergency response. People lay on the ground, shaking and unable to breathe.[2] We can only imagine what the human impact of the record Aliso Canyon natural gas leak in California might have been like had this involved a leak of stored CO_2 instead of natural gas.[3]

The Fundamental Issue with Carbon Management (CDR and CCS) Technologies

CRES recognizes that the current climate change underway is not natural, is entirely the result of human emissions (especially from the burning of fossil fuels), and has enormous negative societal, ecological, and economic consequences. To address it, the world must achieve zero or near-zero carbon emissions as rapidly as possible. Once emissions are eliminated, some forms of CDR will be needed to draw down atmospheric CO_2 and lower the global temperature. However, while some amount of R&D aimed at identifying and developing the most cost-effective CDR methods can be justified, there is little justification for deploying DAC today because its high cost would divert funds from the critical need for rapid deployment of carbon-free energy. Also,

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[1] P.J. Baxter, et al., "Lake Nyos disaster, Cameroon, 1986: the medical effects of large-scale emission of carbon dioxide?" *British Medical Journal*, May 27, 1989. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1836556/#:~:text=Carbon%20dioxide%20was%20blamed%20for,exposure%20to%20an%20asphyxiant%20gas.

[2] Julia Simon, "The U.S. is expanding CO2 pipelines. One poisoned town wants you to know its story," NPR, https://www.npr.org/2023/05/21/1172679786/carbon-capture-carbon-dioxide-pipeline

[3] Aliso Canyon, Wikipedia, https://en.wikipedia.org/wiki/Aliso_Canyon_gas_leak#:~:text=Aliso%20Canyon%20SS%2025%20wellhead,were%20released%20into%20the%20atmosphere

spending funds to apply CCS technologies to fossil fuel power plants makes no sense when solar and wind are now the lowest-cost power-generating technologies.

Thus, given the many demands on federal and state budgets, it is critically important that climate change efforts today avoid the distraction of CDR and CCS, and focus on not emitting carbon dioxide in the first place – that is, on transitioning from carbon-emitting energy sources to the most cost-effective non-carbon sources that can be rapidly deployed, namely renewable energy.

The attention being paid to CDR (especially DAC) and CCS technologies today is clearly an effort by the fossil fuel industry to justify the continued use of fossil fuels, as opposed to achieving the necessary transition to carbon-free energy sources. CRES thus opposes the deployment of DAC and CCS, with the exception that CCS can make sense for limited cases where high-concentration CO_2 process emissions are difficult to avoid, such as in cement production.

It is instructive to view the current rush toward carbon management projects in Colorado in the context of our state history. Over the last half-century, Colorado has experienced a series of costly boom-and-bust energy failures. These failures include the Fort St. Vrain nuclear reactor, the oil shale debacle, the Colorado-Ute Electric Association bankruptcy, underground nuclear blasting for natural gas, the often-inoperable and polluting Pueblo 3 coal-fired power plant, and the destruction of large swaths of Colorado land for fracking. The current rush toward carbon management projects is reminiscent of these other failures, and it distracts us from the fundamental need to rapidly transition off of fossil fuels.

The following text provides additional information on CDR and CCS technologies.

Carbon Dioxide Removal (CDR)

We support limited R&D today to investigate CDR methods that can potentially be used to draw down atmospheric CO_2 in a post-fossil fuel energy economy. In particular, we support R&D of biological, nature-based efforts, which reduce climate change by capturing CO_2 from the air and sequestering it in plants, soils, and sediments. We note, however, that the most immediate need today is to halt deforestation around the world.

Unfortunately, fossil fuel industry lobbying efforts are resulting in a great deal of attention being paid to DAC. The key problem with DAC is that, despite CO_2's powerful activity as an absorber of outgoing infrared radiation, it is a trace gas in the atmosphere constituting only 0.04% of the air. Because atmospheric CO_2 is so extremely diluted, directly capturing it requires moving tremendous amounts of air, and that consumes an enormous amount of electric power to operate large fans. Because of the low concentration of CO_2 in the air, a very large surface area of sorbent material is needed to capture the CO_2, which means that materials and capital equipment costs are very high. Finally, an amount of energy on the order of about four times the fan power, with its own greenhouse gas and pollution implications, is needed to extract the CO_2 after it is captured by the sorbent, and more energy is needed to pump the CO_2 into geological storage locations.

As shown in the table below[4], DAC is also extremely expensive compared to other CDR methods. MIT expert Howard Herzog has estimated that it may be years before DAC drops

[4] J. Sekera, et al., "Carbon dioxide removal-What's worth doing? A biophysical and public need perspective, PLOS Climate, February 14, 2023, https://journals.plos.org/climate/article?id=10.1371/journal.pclm.0000124

below a cost of $600 per ton of CO_2,[5] which is about three times EPA's latest estimate of the social cost of CO_2 emissions. Because DAC uses century-old technology (fans, pipes, pumps, heat, and mass transfer equipment) and common sorbents, it is very unlikely to see the cost reductions that we have seen for solar and wind power. The cost of DAC per ton of captured CO_2 may never be lower than the social cost of carbon.

Table 1. Comparison of the financial cost of mechanical and biological methods of CDR.

Method	Cost/tCO2 captured or removed	Source
Direct Air Capture, *gross* capture, and *excluding* costs of compression, transport & storage	$500* - $1,100	[21, 36, 69, 70]
Reforestation/Afforestation	$20 or less	[18]
Improved forest management	$20 or less	[18]
Improved agricultural practices	$100 or less	[18]
Coastal blue carbon	$20 or less	[18]

* Lower cost estimates exist in the literature (including < $100/ton) but generally come from sources close to industry; upper range estimates are generally derived from thermodynamic considerations [e.g., 21, 36, 69].

https://doi.org/10.1371/journal.pclm.0000124.t001

Carbon Capture and Storage (CCS) at Power Plants

New power plants employing pre-combustion capture were considered to have the potential for the lowest cost because they start with the highest concentration of CO_2, and so various efforts around the world have built Integrated Gasification and Combined Cycle (IGCC) power plants. However, the complexity and costs have generally turned out to be higher than expected. The Kemper coal IGCC plant was shut down in 2017 due to high complexity, concerns about start-up risks, and the ascendancy of natural gas in the market.[6] And because solar and wind are now the lowest cost sources for new electricity generation, it makes no sense to build a new fossil fuel power plant employing pre-combustion capture as it would be much more expensive.

In the case of oxy-combustion, there is a considerable amount of energy and cost associated with extracting oxygen from the air. Oxy-combustion has been used by the gas industry. The only attempt to date to use it in a power plant was the White Rose plant in the UK, but construction was halted in 2016 due to lack of funds.[7] Net Power has had plans to build an oxy-combustion plant in Texas that uses carbon dioxide as the working fluid in the power cycle, but the project has been delayed due to global supply chain issues and is not expected to operate until 2028.[8]

[5] "Affordable direct air capture: myth or reality?," MIT Joint Program on the Science and Policy of Global Change, June 8, 2022, https://climate.mit.edu/posts/affordable-direct-air-capture-myth-or-reality

[6] Kristi E. Swartz, "The Kemper project just collapsed. What it signifies for CCS," E&E New, February 26, 2021, https://www.eenews.net/articles/the-kemper-project-just-collapsed-what-it-signifies-for-ccs/#:~:text=The%20project%2C%20which%20was%20half,equipment%20was%20no%20longer%20needed.

[7] "UK government spent £100m on cancelled carbon capture project," BBC News, January 20, 2017, https://www.bbc.com/news/uk-scotland-scotland-business-38687835

[8] Mary B. Powers, Debra K. Rubin, "Developer NET Power Delays $1B Texas Net-Zero Power Plant Start," Engineering News-Record https://www.enr.com/articles/57639-developer-net-power-delays-1b-texas-net-zero-power-plant-start

Net Power also has plans to build a plant on the Southern Ute Indian Reservation.[9] Thus, oxy-combustion for power plants remains in an early development phase.

Much of the discussion lately is about post-combustion capturing of CO_2 from the flue of a coal- or gas-fired power plant. The preferred technology is to use chemical solvents, such as amines. Although used in the chemical and refinery industries, there are no examples of this in full-scale power plants. The concentration of CO_2 in the exhaust varies from as low as 3% in a gas-fired plant to as high as 15% in a pulverized coal plant. Although it is generally assumed that up to 90% of the CO_2 can be captured, rarely has that been achieved on a continual basis. The addition of capture equipment to a plant increases the cost of the plant and reduces the plant efficiency, and so reduces the amount of electricity produced. A report by Professor Mark Jacobson of Stanford[10], which reviewed data from two pilot studies, found that when all carbon impacts are considered, the effective reduction in the plant's emissions would be much less than the 90% claimed and is as low as 30%, although others have pointed out that the results for a new pilot plant are not necessarily reflective of a full-size conventional technology.

Regardless of which of the three technology types is used for CCS at power plants, parasitic energy, or an additional power supply is required to operate them, the costs are significant, and ultimate success is uncertain. The fundamental reason for deploying any of these technologies is to justify the continued extraction and use of fossil fuels. Investing funds in today's very low-cost solar and wind electricity is a much more cost-effective and environmentally responsible way to reduce the carbon emissions associated with electricity production, while avoiding the land disruption, water consumption, and air pollution associated with extracting fossil fuels from the Earth.

The following is a partial list of CRES's concerns about CDR and CCS:

- **CCS has a long history of technical and financial failures**, as described in detail by the Institute for Energy Economics and Financial Analysis.[11] IEEFA has produced comprehensive studies of carbon management and has concluded that "close to 90% of proposed CCS capacity in the power sector has failed at the implementation stage or was suspended early—including Petra Nova and the Kemper coal gasification power plant in the U.S. Further, most projects have failed to operate at their theoretically designed capturing rates. Chevron's Gorgon CCS project in Australia underperformed by 50%.[12] CCS technology has been going on for 50 years, and many projects have failed and continue to fail, with only a handful working. Many international bodies and national governments are relying on carbon capture in the fossil fuel sector to get to net zero, and it simply won't work."

- **CCS is fraught with deception, greenwashing, and a high cost to taxpayers.** According to the Colorado Sun, Bloomberg News has cited reports from Credit Suisse analysts and others estimating carbon capture entrepreneurs will reap up to $52 billion

[9] Coyote Clean Power, https://coyote.energy

[10] M. Jacobson, "The health and climate impacts of carbon capture and direct air capture," *Energy & Environmental Science*, Issue 12, 2019, https://pubs.rsc.org/en/content/articlelanding/2019/ee/c9ee02709b/unauth#!divAbstract

[11] "The carbon capture crux: Lessons learned," Institute for Energy Economics and Financial Analysis, September 1, 2022
https://ieefa.org/resources/carbon-capture-crux-lessons-learned

[12] "If Chevron, Exxon and Shell can't get Gorgon's carbon capture and storage to work, who can?" Institute for Energy Economics and Financial Analysis, April 26, 2022,
https://ieefa.org/articles/if-chevron-exxon-and-shell-cant-get-gorgons-carbon-capture-and-storage-work-who-can

from the uncapped Inflation Reduction Act tax credits in the first 10 years.[13] Of nearly $1 billion in carbon-capture tax credits sought through 2019, $893 million was submitted in ways that didn't meet EPA rules.[14]

- **Parasitic power:** Capture technologies are estimated to cost 25-30% of a plant's power output, driving up the price of electricity by around 80%.[15]

- **The vast majority of captured CO_2 today is used for enhanced oil recovery (EOR).**[16] Occidental Oil and other oil companies are promoting DAC as a CO_2 source for EOR to extend the life of their oil enterprise by decades.[17] Although EOR can allow CO_2 to be sequestered in conjunction with oil drilling operations, DAC is extremely expensive, and the ultimate effect of EOR is to perpetuate the extraction and burning of oil, which contributes to both climate change and air pollution.

- **CDR and CCS are paid for by American taxpayer dollars.** Congress has rewarded the oil and gas industry for their targeted support for the Inflation Reduction Act through the inclusion of a highly lucrative system of tax credits, known as the 45Q. The Bipartisan Infrastructure Law also provides billions of dollars.[18]

- **Adding CCS to power plants would result in a significant increase in the cost of electricity to ratepayers.** According to WyoFile,[19] Wyoming utilities' analyses of the addition of CCS to coal power plants in Wyoming determined that it would increase rates by $22 to $25 per month for the average residential customer and $40 to $104 per month for commercial customers. It would also reduce electrical generation output by more than 30%, exposing ratepayers to additional costs for replacement power.

- **Water requirements for thermal power plants would increase substantially** if CCS is deployed.[20]

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[13] "There Are Fortunes to Be Made in the Carbon Capture Gold Rush," Bloomberg.com, January 11, 2023 https://www.bloomberg.com/news/articles/2023-01-11/there-are-fortunes-to-be-made-in-the-carbon-capture-gold-rush?embedded-checkout=true

[14] Benjamin J. Hulac, "Treasury IG: A decade of carbon-capture tax credits were faulty, Roll Call, April 30, 2020, https://rollcall.com/2020/04/30/treasury-ig-a-decade-of-carbon-capture-tax-credits-were-faulty/

[15] Cory Simon, "Post-Combustion CO2 Capture to Mitigate Climate Change: Separation Costs Energy," *Scientific American*, March 7, 2013, https://www.scientificamerican.com/blog/guest-blog/post-combustion-co2-capture-to-mitigate-climate-change-separation-costs-energy/

[16] David Roberts, "Could squeezing more oil out of the ground help fight climate change?" Vox, Dec. 6, 2019 https://www.vox.com/energy-and-environment/2019/10/2/20838646/climate-change-carbon-capture-enhanced-oil-recovery-eor

[17] Camila Domonske, NPR, December 27, 2023 "This oil company invests in pulling CO2 out of the sky — so it can keep selling crude," https://www.npr.org/2023/12/27/1210928126/oil-climate-change-carbon-capture-removal-direct-air-capture-occidental

[18] "Funding Notice: Bipartisan Infrastructure Law: Carbon Storage Validation and Testing," U.S. Department of Energy, Office of Fossil Energy and Carbon Management, https://www.energy.gov/fecm/funding-notice-bipartisan-infrastructure-law-carbon-storage-validation-and-testing

[19] Dustin Bleizeffer, "Utility: Wyoming's carbon-capture mandate too costly," WyoFile, October 6, 2022, https://wyofile.com/utility-wyomings-carbon-capture-mandate-too-costly/

[20] H. Eldadiry and E. Habib, "Carbon capture and sequestration in power generation: review of impacts and opportunities for water sustainability," *Energy, Sustainability and Society*, February 1, 2018, https://energsustainsoc.biomedcentral.com/articles/10.1186/s13705-018-0146-3

The following are examples of CDR and CCS activity in Colorado that CRES believes should be seriously questioned.

- **The Colorado Oil and Gas Conservation Commission, long a proponent of the fossil fuel industry, had its name changed in 2023, to the Energy and Carbon Management Commission (ECMC)** and is now conducting a study of carbon sequestration.[21] The ECMC anticipates conducting a rulemaking proceeding on carbon topics in the summer of 2024. The agency has released a report on carbon capture and sequestration safety[22] and has signaled its interest in both promoting and regulating carbon management in the state. The ECMC is authorized to seek a replacement of the Environmental Protection Agency regulatory responsibility to review and approve Class VI carbon dioxide injection wells, presumably to speed up the permitting of carbon capture projects in Colorado.[23]

- **Colorado will soon craft regulations that create guardrails to prevent serious safety hazards. These are intended to reduce the serious risks proven to exist for carbon dioxide pipelines.**[24] Sequestration involves risks of leakage and seismic impacts. The Congressional Research Service produced a report that identifies the safety hazards.[25] The State may be considering invoking eminent domain to force pipelines onto private property owners.[26]

- **The Colorado State Land Board has approved a carbon injection exploration lease** in Weld County, potentially to capture CO_2 from a nearby ethanol plant.[27]

- **A utility-sponsored study in Pueblo** has proposed that their community should consider hosting a very expensive combined-cycle methane plant with carbon capture as a way to bring in future tax dollars.[28]

- **A proposed pipeline through Pueblo County** is anticipated to take captured carbon from facilities like a cement plant and deposit them at the Chico Basin Ranch in El Paso County.[29]

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[21] Colorado Senate Bill 23-016, "*Concerning Measures to Promote Reductions in Greenhouse Gas Emissions in Colorado, and, in Connection therewith, making an Appropriation*."
https://leg.colorado.gov/sites/default/files/2023a_016_signed.pdf

[22] *Carbon Capture and Storage: Safety and Impact Considerations from Source to Sequestration*, Colorado Energy and Carbon Management Committee,
https://ecmc.state.co.us/documents/library/GTCCSUNGS/CCS_Safety_Study_Report_20240201.pdf

[23] "Creating Colorado's Carbon Sequestration Framework: A Legislative Proposal," January 2023,
https://ecmc.state.co.us/documents/library/special_projects/CCUS_Framework_Legislative_Proposal.pdf

[24] Julia Simon, "The U.S. is expanding CO2 pipelines. One poisoned town wants you to know its story," NPR, September 23, 2023
https://www.npr.org/2023/05/21/1172679786/carbon-capture-carbon-dioxide-pipeline

[25] Congressional Research Service, "Carbon Dioxide Pipelines: Safety Issues," June 3, 2022
https://crsreports.congress.gov/product/pdf/IN/IN11944

[26] "Creating Colorado's Carbon Sequestration Framework: A Legislative Proposal," January 2023,
https://ecmc.state.co.us/documents/library/special_projects/CCUS_Framework_Legislative_Proposal.pdf

[27] Colorado State Land Board, Carbon Sequestration, https://slb.colorado.gov/Carbon

[28] Pueblo Innovative Energy Solutions Advisory Committee Report, January 2024,
https://www.xcelenergy.com/staticfiles/xe-responsive/Archive/PIESAC%20Written%20Report.pdf

[29] Michael Booth, "Colorado wants to create carbon-capture hubs across the state. But locals aren't sold." The Colorado Sun, November 2, 2023

- **Colorado won a $32 million DOE grant to pay for a carbon capture test well** in the southern part of the state. The grant and the research are managed by the Colorado School of Mines, the Los Alamos National Laboratory, and the private startup, Carbon America.[30]

- **Colorado has won a separate $3 million DOE grant to promote studies and marketing** for a potential direct carbon capture hub centered on Pueblo.[31]

- **A well in Washington County, near Yuma, has already been drilled** as part of a deal that Carbon America worked out with investors to sequester carbon from northeastern Colorado corn ethanol plants.[32]

- **Tri-State Generation and Transmission's December 2023 Electric Resource Plan** envisions adding a 290 MW combined-cycle natural gas unit in 2028, with carbon capture and sequestration added in 2031.[33]

Conclusion

For the reasons stated above, CRES opposes the use of state and federal taxpayer dollars and ratepayer funds to deploy unproven carbon management projects in Colorado. This includes the use of direct air capture (DAC) to remove CO_2 from the atmosphere, and the use of carbon capture and storage (CCS), or carbon capture utilization and storage (CCUS) with fossil fuel power plants.

https://coloradosun.com/2023/09/17/colorado-carbon-capture-future/

[30]Michael Booth, "Colorado gets $32 million to create carbon-stuffing hub underground at Pueblo" The Colorado Sun, May 18, 2023 https://coloradosun.com/2023/05/18/colorado-carbon-sequestration-hub-pueblo-grant/

[31] Michael Booth, "Colorado wants to create carbon-capture hubs across the state. But locals aren't sold." The Colorado Sun, November 2, 2023, https://coloradosun.com/2023/09/17/colorado-carbon-capture-future/

[32]"Tri-State accelerates clean energy transition and bolsters electric system reliability," TRI-STATE, December 1, 2023, https://tristate.coop/tri-state-accelerates-clean-energy-transition

[33] Ibid