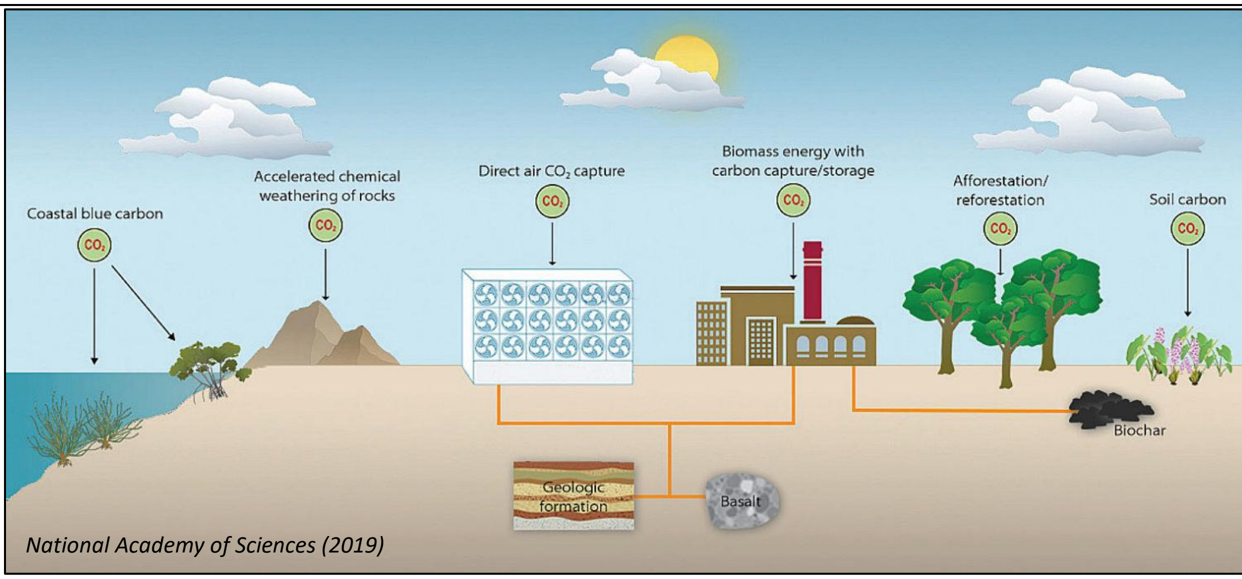
Federal Climate Innovation

Carbon Dioxide Removal: A Must-Have Tool for the Climate Challenge

- Carbon dioxide removal (CDR) refers to a class of natural and technological strategies designed to remove carbon pollution directly from the atmosphere.
- Most analyses suggest that CDR strategies will be critical to achieving net-zero emissions by no later than 2050. With innovation and investment, emerging technologies have the potential to remove billions of tons of CO_2 from the atmosphere each year.
- Carbon removal is not a substitute for action to slash emissions now or an excuse to delay climate action. Enforceable limits on emissions, rapid clean energy deployment, strong mitigation policies across every sector, and nature-based and technological CDR are *all* needed to avoid the worst impacts of climate change.



National Academy of Sciences (2019)

What is carbon dioxide removal?

Carbon dioxide removal (CDR) is an emerging set of strategies to remove carbon pollution from the atmosphere. CDR provides a powerful tool for tackling climate change – unlike technologies that reduce carbon emissions, CDR removes carbon pollution directly from the atmosphere. A range of approaches are classified as CDR, including both natured-based strategies like reforestation and engineered solutions like direct air capture (DAC) systems.

Why do we need carbon dioxide removal technologies?

To avoid the worst impacts of climate change, the U.S. will need to transition to a net-zero emissions economy by 2050, one that produces no more carbon emissions than we can remove. To date, most climate change mitigation efforts have focused on emissions abatement – reducing the amount of pollution released – and this should remain the top priority. However, with CDR, we also can reduce the amount of pollution *already* in the atmosphere.

CDR is not an alternative to rapid clean energy deployment or carbon pollution limits but pursuing CDR *alongside* more traditional carbon reduction strategies is essential to achieve a net-zero emissions economy in the necessary time frame. According to the IPCC, all emissions pathways that limit planetary warming to 1.5°C by the end of the century without overshoot, and 87% of pathways that limit warming to 2°C, rely on large-scale atmospheric CDR.[i] And the National Academy of Sciences finds that, even with aggressive emissions cuts, the world will need to remove 10 billion tons of CO_2 per year by midcentury to meet Paris targets.[ii] While CDR includes nature-based strategies, such as reforestation, most models also lean on technological solutions, including DAC, carbon mineralization, and bioenergy with carbon capture and storage (BECCS). Analyses by Rhodium Group and Realmonte, et. al. suggest that excluding technological CDR would make it nearly impossible to achieve our emissions targets in the time frame needed.[iii,iv]

However, issues of CDR governance and social, economic and energy justice must be seriously considered. There are concerns that investments in CDR will reduce the urgency to mitigate emissions or could even be used as a justification to perpetuate fossil fuel production. Questions of who shapes CDR policy, who benefits from CDR deployment, and who faces potential adverse environmental and social consequences from these strategies should be considered by policymakers, researchers and communities as CDR approaches scale up. These questions have implications for equity both at a local and global scale.

CDR Approaches

Nature-based strategies encompass the array of techniques to expand nature's carbon sinks. They are also commonly referred to as "natural climate solutions." Their potential to draw down CO_2 is modeled in IPCC reports within the Agriculture, Forestry, and Other Land Use (AFOLU) or Land Use, Land Use Change, and Forestry (LULUCF) sectors. These strategies include the restoration of forests and soils, which serve as natural carbon storage systems; development of climate-friendly agricultural practices, such as restoring wetlands and riparian buffers, planting perennial strips within fields and switching from annual to perennial crops; and avoiding land use changes which result in release of currently stored carbon, such as deforestation or plowing pastures.

- **Advantages:** Can be implemented with existing technologies; low-cost; provide a variety of co-benefits for air and water quality, food security, biodiversity and more.
- **Challenges:** Land use conflict with other human interests; vulnerable to climate change impacts, like wildfires and soil warming, which can reverse progress; soil carbon will become saturated over time; measurement requires long-term monitoring, reporting and verification.

Climeworks direct air capture facility in Iceland

Direct air capture (DAC) involves the removal of carbon dioxide from ambient air by passing it through a chemical filter. The captured CO_2 can then be used in fuels or manufactured products or sequestered in the ground. DAC is a proven technology, currently in use at several pilot plants in North America and Europe, and at one commercial facility in Switzerland which opened earlier this year. Still, to achieve net-zero emissions by 2050, the U.S. may require 560 to 1,850 million metric tonnes of direct air capture and sequestration per year.[iii]

- **Advantages:** Potential large scale; small physical footprint relative to other forms of CDR; less vulnerable to climate change than land-based solutions.
- **Challenges:** Capital-intensive; demands significant new, cheap and clean electricity sources; requires certain local conditions or pipeline infrastructure to enable geologic sequestration.

Bioenergy with carbon capture and storage (BECCS) involves harvesting crops to either burn for energy or to produce liquid fuel alternatives, and then capturing associated CO_2 emissions and permanently sequestering them in geological formations. This is considered a CDR technology because the crops draw CO_2 from the atmosphere as they grow – and with sequestration, that CO_2 is never re-released into the atmosphere.

- **Advantages:** Generates low-carbon energy; possible fuel production pathway for hard-to-abate sectors.
- **Challenges:** High demand for land and nutrients can impact habitats and other CDR efforts, potentially creating new GHG emissions sources; land devoted to biofuel crops could compete with food crops, which could result in indirect land use changes that increase emissions.

Nascent CDR Strategies have also started drawing international attention but have not yet been widely demonstrated. These include enhanced mineralization and ocean alkalinization; seawater capture, a process similar to DAC; and ocean fertilization to stimulate marine photosynthesis.

[i] IPCC. (2018). Special Report: Global Warming of 1.5°C. https://www.ipcc.ch/sr15/chapter/chapter-2/
[ii] National Academy of Sciences. (2019). Negative Emissions Technologies and Reliable Sequestration. bit.ly/2kGjSwy
[iii] Larsen, J., Herndon, W., Grant, M., & Marsters, P. (2019, May 9). Capturing Leadership: Policies for the US to Advance Direct Air Capture Technology. *Rhodium Group*. bit.ly/2KkNwC7
[iv] Realmonte, G., Drouet, L., Gambhir, A., Glynn, J., Hawkes, A., Koberle, A.C., & Tavoni, M. (2019, July 22). An inter-model assessment of the role of direct air capture in deep mitigation pathways. *Nature Communications*. go.nature.com/2kHwcfQ

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