DIRECT AIR CAPTURE

WHAT IS DIRECT AIR CAPTURE WITH CARBON STORAGE?

Direct Air Capture with Carbon Storage (DACCS) is an approach to carbon removal in which mechanical systems capture carbon dioxide (CO_2) directly from the atmosphere and compress it to be injected into geological storage or used to make long-lasting products, such as cement. There are a variety of technologies for doing this. Some use chemicals that bind with CO_2 in the air and release the CO_2 when heated. Others use changes in temperature, humidity, or electrical charge to capture and release CO_2.

Other uses of direct air capture technology, such as using captured CO_2 in greenhouses or to manufacture synthetic fuels, are a form of carbon capture and use or "carbon recycling" because the CO_2 returns to the atmosphere quickly after the products are consumed. Synthetic fuels made with direct air capture ("air-to-fuels") could still contribute to mitigating climate change by displacing fossil fuels.

CO-BENEFITS AND CONCERNS

+ **Carbon capture and use:** direct air capture produces a stream of pure CO_2, which can be used to make long-lasting products, such as low-carbon cement, in a "carbon-to-value" supply chain. Use in short-lived products amounts to carbon recycling, not carbon removal.

− **Energy demand:** DACCS processes require significant amounts of energy, which must be low-carbon to maximize the technology's climate impact. Diverting low-carbon energy to DACCS competes with emissions reductions and may require large areas of land.

− **Concerns about geologic storage:** transporting and injecting CO_2 into geological reservoirs raises concerns about pipelines, CO_2 leakage, seismic activity, and water pollution.

− **Enhanced oil recovery:** captured CO_2 is sometimes pumped into declining oil wells to increase output, which critics argue prolongs the fossil fuel industry and undermines the carbon benefits of DACCS.

POTENTIAL SCALE AND COSTS

The potential scale of carbon removal via DACCS could be very large because it requires far less land than approaches like BECCS and forestation and because it could be sited near appropriate geological reservoirs, avoiding the need for extensive pipelines. However, the potentially high costs and the need for large amounts of low-carbon energy impose practical constraints on upscaling DACCS. Cost estimates vary widely. In recent years, costs have reportedly hovered around $600 per ton of CO_2 captured. Carbon Engineering claims its Texas facility will capture CO_2 at around $200 per ton, and **several companies project costs to fall to around $100 per ton or even less.** An **independent expert assessment in 2018 projected costs of $100–300 per ton of CO_2**. That same assessment estimates potential sequestration **rates of 0.5–5 billion metric tons of CO_2 per year in 2050, with a theoretical longer-term potential in the tens of billions of tons per year.**

DIRECT AIR CAPTURE

TECHNOLOGICAL READINESS

A handful of companies currently have direct air capture facilities in operation, all in North America or Europe, and a growing number of start-ups are exploring new approaches to or uses for direct air capture. **Most existing facilities are small, capturing tens to hundreds of tons of CO_2 per year, and with one exception, existing facilities re-use the captured CO_2 rather than sequestering it. This is poised to change in the near future.** A Swiss company, Climeworks, is currently expanding its DACCS plant in Iceland, which will sequester thousands of tons of CO_2 per year as part of the CarbFix2 project. A Canadian company, Carbon Engineering, has partnered with an arm of Occidental Petroleum to build a DACCS plant in Texas that will capture roughly one million tons of CO_2 per year and use it for enhanced oil recovery.

GOVERNANCE CONSIDERATIONS

- **Monitoring, verification, and reporting of sequestration:** good policies and standards need to be developed or adapted for monitoring, verifying, and reporting the reliable, long-term sequestration of CO_2.
- **Promotion of appropriate upscaling:** DACCS is unlikely to develop at scale without policy support in the form of subsidies or carbon pricing and advances in policy support for geological storage of CO_2.
- **Identification and support for appropriate niche markets:** niche markets for captured carbon, such as long-lived products and synthetic fuels, could play a role in the development of DACCS technologies, but reliance on some of these uses, especially enhanced oil recovery, threatens to undermine DACCS' environmental benefit in direct and indirect ways.
- For **cross-cutting considerations**, see the What Is Carbon Removal? fact sheet on our website.

FURTHER READING

Fasihi, M. et al.. 2019. "Techno-Economic Assessment of CO_2 Direct Air Capture Plants." *Journal of Cleaner Production* 224: 957–80. doi 10.1016/j.jclepro.2019.03.086.

Fuss, S. et al. 2018. "Negative emissions—Part 2: Costs, Potentials and Side Effects." *Environmental Research Letters* 13: 063002, doi 10.1088/1748-9326/aabf9f.

National Academies of Sciences, Engineering, and Medicine. 2019. *Negative Emissions Technologies and Reliable Sequestration: A Research Agenda*. Washington, DC: The National Academies Press.

Larsen, J. et al. 2019. *Capturing Leadership: Policies for the US to Advance Direct Air Capture*. New York: Rhodium Group.

For more fact sheets on carbon removal, visit https://carbonremoval.info/factsheets.

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