EsadeGeo-Center for Global Economy and Geopolitics

Technologies of the energy transition: Direct Air Capture

EsadeGeo Event Brief
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This EsadeGeo Event Brief draws insights from the webinar Technologies of the energy transition: Direct Air Capture of CO_2*, organised by EsadeGeo and the Repsol Foundation. For this brief, the speakers' insights were complemented with findings from the most recent literature on the topic.*

The technology

Direct Air Capture (DAC) is a technological process that **separates CO_2 emissions directly from the air**. The source of the captured CO_2 makes DAC distinct from Carbon Capture, Use and Storage (CCUS) technologies that trap CO_2 emissions directly at the point of emissions (from flue gases). DAC involves using large-scale fans to suck in ambient air, which is then passed through a liquid solvent or solid sorbent to separate CO_2, in a concentrated form, from other gases. The resulting captured CO_2 can either be used directly (for example, in the beverage industry or to produce synthetic aggregates or synfuels) or stored geologically.[1]

The opportunity: Which sectors can this technology help to decarbonize?

Given that DAC removes CO_2 from *ambient* air, it is not a sector-specific technology. Rather, it is a complementary technology that may contribute to the **pursuit of carbon neutrality**, or even generate **net negative emissions** through permanent CO_2 removal (storage).

In order to achieve the temperature goals of the Paris Agreement, net zero emissions targets are starting to appear around the world (Darby, 2019), for example by 2050 in the EU. Reaching these targets will require rapid decarbonization in all sectors. Nevertheless, it is likely that some emissions may remain (in hard-to-abate sectors, for example), and in these cases, DAC provides an option to cover the final mile. In addition, the longer it takes to decarbonize the global economy, the more likely it becomes that DAC and other negative emissions technologies (both in the biosphere and the geosphere) will be necessary to diminish the stock of already emitted CO_2 in the atmosphere[2] (Friedmann, 2020).

[1] Less developed methods of DAC are also under study and development, including the use of membranes to catch carbon from seawater and cryogenics to separate CO_2 from the air respectively (Sandalow et al., 2018).
[2] This stock is sometimes called "legacy CO_2". Due to the global warming potential and atmospheric lifetime of CO_2, these stocks will continue heating the atmosphere for centuries once emitted.

The reality: What stage of development and deployment is the technology currently at?

Both liquid and solid DAC currently stand at a Technology Readiness Level 6, with **full prototypes at scale in operation** (IEA, 2020). As of 2020 there are three companies running some 15 plants in Europe, the US and Canada (Budinis, 2020).

- Carbon Engineering, a Canadian-based firm, uses liquid solvent-based DAC in a plant whose captured CO_2 is then employed for synfuel production.
- Climeworks and Global Thermostat, on the other hand, use solid sorbent-based DAC (IEA, 2020).
- The technology of Climeworks has been installed in Switzerland, Iceland and Italy; it is the first firm to offer an offset mechanism to individuals and entities (turning CO_2 removed from the atmosphere into stone) (IEA, 2020) and it is currently exploring utilizing captured CO_2 to produce synfuels (Climeworks, 2020).
- A first large-scale DAC plant, whose captured CO_2 will be used for enhanced oil recovery, is currently under development by Carbon Engineering in partnership with Occidental Petroleum (Budinis, 2020).

If, as multiple authoritative studies have suggested (McQueen et al., 2020), large-scale carbon removal will be necessary to reach global climate goals, DAC will need "to be demonstrated at scale, sooner rather than later, to reduce uncertainties regarding future deployment potential and costs" (IEA, 2020).

The hurdles: What are the major obstacles/challenges preventing further uptake?

DAC is currently still an **expensive** technology. One of the main reasons is the source of the captured emissions: in working with ambient air rather than directly at the point of emissions (e.g. a factory stack), the concentration of CO_2 is far lower, which makes separating the CO_2 out more **energy intensive**. In addition, if the captured CO_2 is to be stored geologically rather than used directly, this increases operational and capital costs further, due to the compressor and energy needed for injection (Budinis, 2020).

Estimates of capture costs range widely, from USD 100/ton to USD 1000/ton (Budinis, 2020); however cost estimates have been declining rapidly.[3] In general, the cost of the DAC is likely to vary as a function of deployment. At this stage, **demonstrating the technology at scale** (Budinis, 2000) and **generating markets** for DAC as well as its captured CO_2 will be critical. Policies such as standard-setting, investments in innovation and carbon pricing, among others, can play a large role in this phase (Friedmann, 2020).

[3] Whereas a range of USD 673-1172/ton range was projected in the past, the first commercial-scale plant is currently estimated in the range of USD 124-325/ton (Larsen et al., 2019). In the liquid solvent pathway, Carbon Engineering is currently projecting costs of USD 92-150/ton; while in solid sorbent pathways, Climeworks estimates it can reach USD 200/ton in five years and Global Thermostat projects $150/ton (Friedmann, 2020).

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