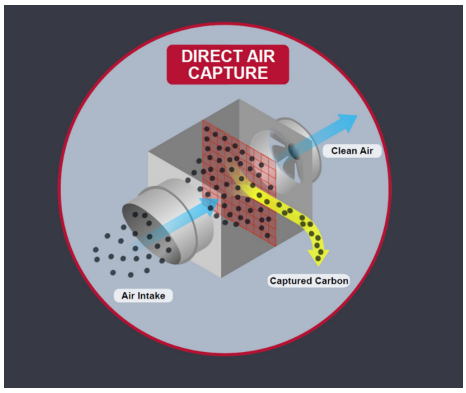
Direct Air Capture Explained



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Direct air capture is a technology that directly separates planet-warming carbon dioxide (CO_2) from the atmosphere for permanent, safe geologic storage or the manufacture of clean, low-carbon fuels and chemicals. Building and operating direct air capture facilities has the potential to create well-paying manufacturing jobs across the United States.

Direct air capture is an integral part of the carbon dioxide removal portfolio that the United States will deploy to reduce the concentration of CO_2 in the atmosphere. The United Nations' Intergovernmental Panel on Climate Change notes that the deployment of carbon dioxide removal technologies like direct air capture is necessary to cancel out emissions from certain sectors like aviation that will be difficult to address in other ways.

This technology is distinct from carbon capture, which is a related-but-different solution for reducing emissions. Whereas carbon capture technologies minimize emissions from stationary sources like industrial facilities and power plants, direct air capture technologies remove carbon directly from the ambient air.

The ability of direct air capture facilities to function in the absence of existing sources of emissions provides geographic flexibility due to the even distribution of CO_2 in the atmosphere. This flexibility allows the location of direct air capture plants close to geologic storage sites and clean energy resources, which gives the facility the ability to operate effectively in any number of jurisdictions or locales.

While the field of direct air capture is still in its infancy, recent investments in research and development made possible by the Bipartisan Infrastructure Law and the Inflation Reduction Act dramatically increase the likelihood of achieving breakthroughs. These breakthroughs will help direct air capture scale up much more quickly, create lasting benefits in more communities around the country, and maximize positive environmental impacts of the technology.

There are two primary technical approaches to direct air capture involving adsorption of CO_2 that are being deployed today:

1. Solid sorbent systems that use sorbent materials to capture CO_2 from air.
2. Liquid solvent systems that use liquids to capture CO_2 from air.

There are a wide variety of different liquid solvents and solid sorbents used to capture carbon from the air and a wide variety of processes for separating the CO_2 from these materials after being captured. Researchers and companies are testing many different combinations to find the optimal strategy for cost reduction and technical feasibility.

How Adsorption of CO_2 in Direct Air Capture Works

- **SOLID SORBENT** systems occur on the surface of the capture material, like Velcro sticking to cloth. Adsorption processes use a solid capture material with a high affinity for CO_2 for capture purposes. Once CO_2 is captured, a "swing" of some condition or combination of conditions—such as temperature, pressure, and/or humidity—is applied to the sorbent to release higher-purity CO_2 in a controlled environment for subsequent storage or conversion. Desorption regenerates the sorbent, usually with only minor losses, allowing for the sorbent material to be continuously recycled in the direct air capture process.
- **LIQUID SOLVENT** systems use liquids imbued with chemicals, known as solvents, that attach to CO_2 molecules for selective separation from the air. Once these solvents are carbonated, they can be processed in a variety of ways that release higher-purity CO_2 in a controlled fashion for subsequent storage or conversion, similar to sorbent-based processes. Solvents are then recycled for continuous use in the system.

The U.S. Department of Energy is supporting research, development, and at-scale demonstration of the wide variety of direct air capture technologies in each category at the pre-commercial and commercial stages. Continued research, development, and demonstration improvements will decrease the cost and energy requirements of operating direct air capture facilities, allowing for cheaper and more efficient future deployment around the country.

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