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Technology and Costs

TECH 2023S8: Direct Air Capture Technologies

Direct Air Capture Technologies is one in a series of reports published as part of NexantECA's 2023 Technoeconomics – Energy & Chemicals (TECH) program.

Overview

Direct air capture (DAC) technology is being seen by many in the industry as essential in achieving net zero goals but is currently hampered by its large energy requirements and high costs, causing many in the industry to contemplate engagement and investment.

DAC is a carbon dioxide capture approach that involves removing CO_2 directly from the atmosphere to reduce atmospheric CO_2 concentration levels and offset CO_2 emissions from difficult to decarbonize sectors. The technology has received increasing attention in recent years due to global decarbonization efforts and net zero targets, as well as policy frameworks and corporate sector investment supporting the technology.

This TECH report provides an overview of DAC technology and economics, as well as market aspects and climate landscape in terms of key policies and project status. More specifically, the report covers:

- DAC technology overview, including process descriptions, key challenges and limitations, advantages and disadvantages, and areas for cost-reducing innovation
- Detailed review of sorbent- and solvent-based DAC approaches, with a minor focus on other developmental DAC methods such as moisture/humidity swing adsorption, cryogenic, electrochemical/electro-swing adsorption, and membrane-based DAC technologies
- Key players and technology holders/licensors of DAC technology as well as an overview of pre-commercial DAC technology developers
- Base-case cost of CO_2 capture estimates for sorbent- and solvent-based DAC processes with comparative process economics and comparison for different regions

Technology Overview

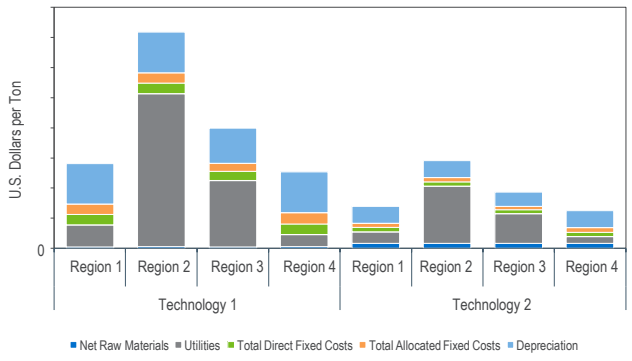
While still in its early developmental stages (TRL 6) solid sorbent and liquid solvent DAC approaches are currently furthest along in development compared to other methods. Typically, hydroxides and amines are used to separate CO_2 from incoming ambient air, either introduced as functional groups attached to the surface of a solid material (sorbent DAC) or as aqueous solutions (liquid solvent DAC). The CO_2 is then released as a concentrated stream and the sorbent/solvent is regenerated through application of heat, or other energy input.

The main technology challenges faced by DAC, contributing to its current high cost and high energy demands are primarily due to:

- Difficulty of separating the low concentration of CO_2 (~400 ppm) in the air
- Energy requirements associated with processing large volumes of air
- Challenge of achieving a low pressure drop across the air contactor unit
- Tradeoff between achieving strong sorbent/solvent interactions with CO_2 to capture it from air while minimizing energy requirements to release the CO_2

Process Economics

Detailed cost of CO_2 capture estimates are presented for a generic solid sorbent DAC system and a KOH solvent DAC system with a calcium caustic recovery loop for regeneration. Costs are presented in Q1 2023 dollars for the United States Gulf Coast, Western Europe, Southeast Asia, and the Middle East. Sensitivity analysis is also included to consider potential cost reductions from tax credits through the US government's Inflation Reduction Act (IRA).



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The TECH program (formerly known as PERP) is globally recognized as the industry standard source of process evaluations of existing, new and emerging technologies of interest to the energy and chemical industries.

TECH's comprehensive studies include detailed technology analyses, process economics, as well as commercial overviews and industry trends. Reports typically cover:

- Trends in chemical technology
- Strategic/business overviews
- Process Technology:
- Chemistry
- Process flow diagrams and descriptions of established/conventional, new and emerging processes
- Process economics – comparative costs of production estimates for different technologies across various geographic regions
- Overview of product applications and markets for new as well as established products
- Regional supply and demand balances for product, including capacity tables of plants in each region
- Regulatory and environmental issues where relevant

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Technology and Costs comprises the Technoeconomics – Energy & Chemicals (TECH) program, the Biorenewable Insights program (BI), and the new Cost Curve Analysis. These programs provide comparative economics of different process routes and technologies in various geographic regions.

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