Direct Air Capture cost reduction and market development via process intensification. Establishing the DAC insetting concept.

Albert Pujol[1]*, Mads Heuckendorff[2], Thomas H. Pedersen[1]
[1]Department of Energy, Aalborg University, Pontoppidanstræde 111, 9220 Aalborg Ø, Denmark
[2]COWI A/S Green Fuels and Energy, Visionsvej 53, 9000 Aalborg, Denmark
*Corresponding author. E-mail: apdu@energy.aau.dk, Tel. +45 52 80 38 80

Abstract

Direct Air Capture (DAC) technologies are anticipated to achieve megaton-scale by 2030 and gigaton-scale by 2050. However, current capture costs and pace of development cast doubt on DAC's readiness to contribute to the environmental goals in the 2030s. This study introduces an innovative framework to reduce capture costs and facilitate the widespread deployment of DAC technologies. First, an extensive review of the current state of DAC deployment is conducted, followed by an analysis of the DAC market outlook. Secondly, the methodology involves the techno-economic assessment of our case study, the integration of absorption-based DAC systems with urea manufacturing. As a result, two First-of-a-kind (FOAK) DAC plant designs based on process intensification are formulated (DAC-to-urea). FOAK costs are projected into the future by outlining distinct deployment scenarios using the learning rates principle. Estimates from the optimistic deployment case indicate that low renewable electricity prices and ambitious learning rates lead to competitive DAC-based urea prices (589- 710 $/t urea), while achieving promising capture costs (158-248 $/tCO2). In that context, renewable ammonia generation acts as the primary bottleneck for sustainable urea production employing air-captured CO2. This outcome strengthens DAC-CO2 role as a chemical feedstock for high-demand commodities in future sustainable economies. However, results derived from the delayed deployment scenarios (280- 590$/tCO2) align with innovative cost assessment approaches from the literature. Findings highlight the dependency of DAC cost predictions on elevated learning rates and immense increases in capacity.